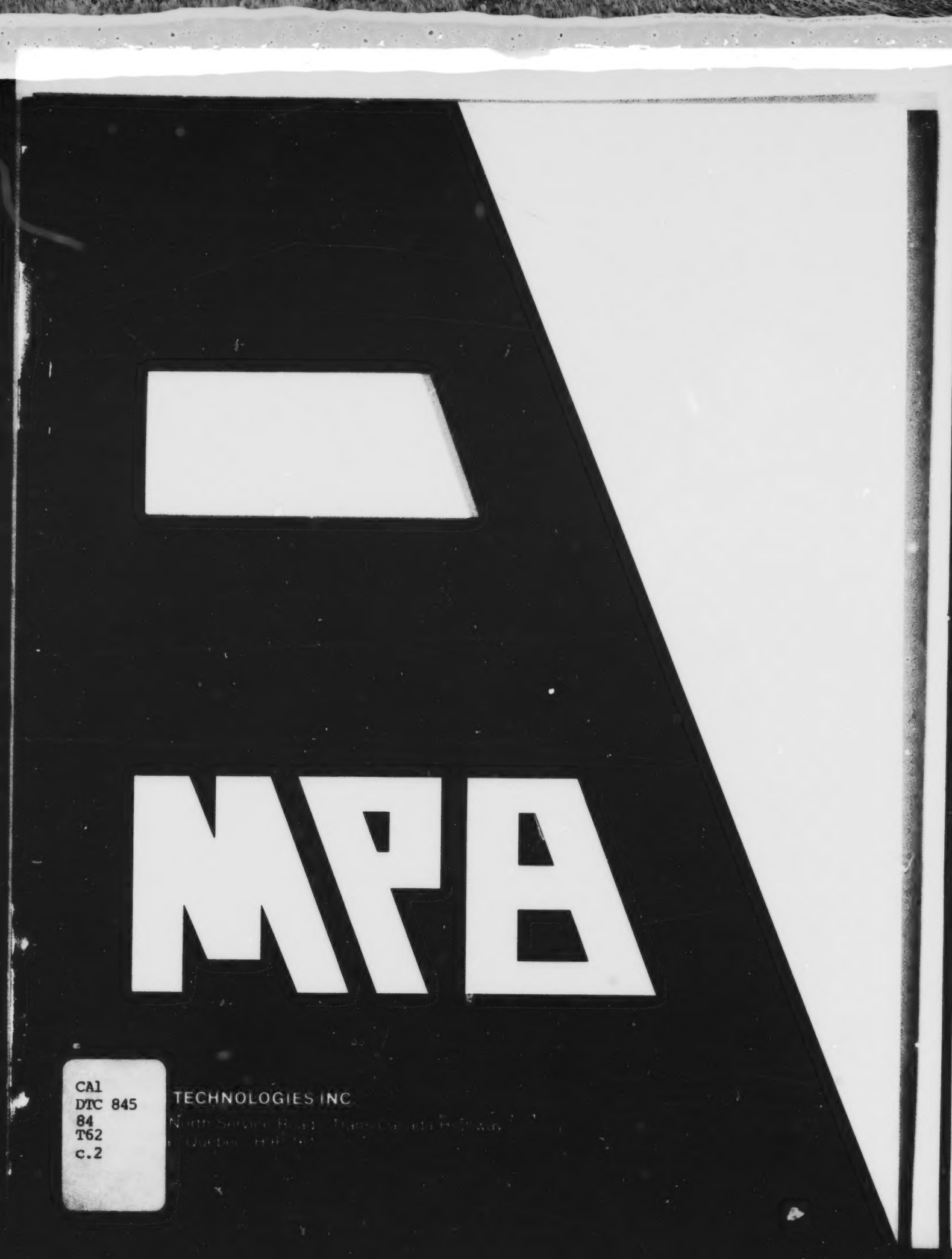


CA1
DTC 845
84
T62
c.2

TECHNOLOGIES INC
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MPB

TP 5105 E

# TRAIN DATA RECORDING SYSTEM

FINAL REPORT
Prepared for the
TRANSPORTATION DEVELOPMENT CENTRE.

by

R.J. Clark,
A.G. Ferguson,
G.F. Guevara.

May, 1984.

MPB Technologies Inc.
1725 North Service Road,
Trans Canada Highway,
Dorval, Quebec,
H9P 1J1.

PROJECT TEAM

The project team for MPB Technologies Inc. comprised:

Mr. R.J. Clark

Mr. A.R. Ferguson

Mr. G. Guevara

Mr. A. Evers

and others

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre.

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17. Abstract

This report presents the results of the two-phase research and development program aimed at developing a completely solid state, microprocessor controlled train data recording system (TDRS). The preliminary design and fabrication of a prototype TDRS consisting of a recording unit for installation on a locomotive, a portable memory unit for transferring data from locomotive to site of the playback system which itself consists of a keyboard, CRT display, control unit and printer, is documented. A final specification with schematic and block diagrams, as well as a description of the recording system equipment, is included.

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| 15. Remarques additionnelles | 16. Agent de projet — CDT<br>W.G. Rowan |

17. Résumé

Ce rapport rend compte des travaux des deux phases du programme de recherche et de développement visant à mettre au point un système d'enregistrement des paramètres de fonctionnement d'un matériel roulant, système complètement transistorisé et commandé par microprocesseur. Il présente l'étude préliminaire ainsi que le montage sur table d'un prototype comportant un enregistreur embarqué et une mémoire portative pour transférer les données enregistrées à l'unité de lecture, celle-ci étant elle-même formée d'un clavier, d'un écran cathodique, d'un organe de commande et d'une imprimante. Enfin, il propose un projet finale de devis pour le matériel d'enregistrement envisagé, accompagné des schémas de principe et fonctionnel.

| 18. Mots-clés | 19. Diffusion |
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| Matériel roulant, locomotive, enregistreur de données, microprocesseur, ordinateur | Le CDT dispose d'un nombre limité d'exemplaires. |

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English on reverse

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## 1.0 INTRODUCTION

Canadian railway officials have indicated that there is a need for a rugged, reliable economic train data recording system capable of logging some twenty or more parameters over a continuous period of two days or longer. Such a system would employ a recorder mounted in the locomotive, optional CRT display unit for the engineman, playback unit consisting of a keyboard control unit, CRT monitor, dual floppy disk drives and optional printer in a fixed location and a portable memory transfer unit. Existing train recording equipment has been based on magnetic tape recorders which have suffered mechanical failures attributable to the harsh locomotive operating environment.

MPB Technologies Inc., with the cooperation and endorsement of CP Rail, responded to the need by proposing to develop an all solid state microprocessor controlled train data recording system under a two-phased program described in its unsolicited proposal submitted to Department of Supply & Services in early April, 1981. The proposal was accepted in principle by the Department of Industry, Trade & Commerce and the Canadian Transport Commission, and directly sponsored by the Department of Supply & Services and the Transportation Development Centre, and is now being implemented.

The project objective is to develop a solid state microprocessor controlled train data recording system (TDRS) in which the recording unit itself is installed in locomotives. The specific objective is to produce a final detailed design package suitable for calling tenders for quantity production of all newly developed components of such a TDRS. Some components of the system (hardware as well as software) which existed at the time the contract was awarded, remain the property of MPB Technologies Inc.

In order to achieve the specific objective, a comprehensive two-phase, staged design, prototype fabrication, laboratory and field test evaluation program has been undertaken over a period of approximately two years.

Phase I of the project included the preliminary design and fabrication of a «breadboard» prototype TDRS unit, elements of which have been functionally tested in both the laboratory and in the field to verify the design. The «breadboard» system consisted of a recording unit which was installed on a locomotive site to the playback system, which itself included a keyboard. control unit and printer. All system components, except the printer, have been designed, fabricated and tested with the recorder unit actually installed on a CP Rail locomotive. System design modifications have been made in Phase II based on test results from the «breadboard» system.

The second phase involved the construction of two portable memory units, six prototype recording units and two complete playback units. Five recording units, one portable memory unit and one playback unit is available to CP Rail for field trials. Environmental and vibration tests are being independently conducted on the first prototype unit to ensure that the design meets the specifications in Appendix 'C'. A final design package has been produced.

All objectives of Phase I and Phase II programs have been met, with the exception of the color graphics display. Only a summary will be presented in the main report, while the details are presented in the appendices.

## 2.0 SYSTEM DESCRIPTION

### 2.1 General

Figure 1 is an application diagram illustrating the implementation of the Train Data Recording System.

The recorder system, mounted in the locomotive, records the train operating parameters listed in Figure 2 and stores the recording in a solid state memory for later playback.

The portable memory unit extracts the recording from the recorder and permits the recording to be transported to the playback system.

The playback system stores the recording received from the portable memory on a floppy diskette for playback in a variety of ways on a CRT display and/or printer unit.

The detailed recorder wiring schematic provided in Figure 3 shows the external signals that are brought into the junction box.

The diagram in Figure 4 shows the wiring between the mounting base and the recorder unit input connectors.

Figures 5, 6 and 7 are block diagrams of the recorder unit, portable memory unit, and playback system respectively.

Figure 8 consists of photographs of the various system components.

### 2.2 Recorder System

The recorder system comprises a microprocessor controller and a series of sensors and transducers. The microprocessor controller is shown in detail in the Figure 5 block diagram.

In response to the respective keyboard command the microprocessor controller under software controller reads the various sensor data and stores the readings, as required in the solid state memory.

At the completion of a run (or at any convenient time as determined by the railroad) the recording is extracted by the portable memory, or by some other external system, for replay by the playback system.

Details of the train data recorder system operation and operating characteristics are provided in the TDRS Specification in Appendix A and User's Manual in Appendix B.

## 2.3 Playback System

The playback system shown in Figures 1 and 7 comprises the following main components:

- microprocessor controller with color monitor and dual disk drives
- keyboard unit
- printer unit

In response to the respective keyboard command, the microprocessor controller requests the recording from the portable memory (or recorder directly) and stores it in memory for analysis. The recording can be reviewed on the CRT or printed by the printer in a variety of ways, as determined by instructions by the keyboard operator.

The keyboard operator can request to see portions of the recording in which specified parameters match conditions set up by the operator. For more information see the playback section of the User's Manual in Appendix B.

A permanent copy of the recording can be made on a diskette for future recall and analysis.

## 2.4 Portable Memory

The portable memory shown in Figure 1 and 5 is merely an extension of the playback system without the keyboard, CRT display and printer units.

It comprises a battery operated microprocessor controller with a large solid state memory.

When the memory dump cable is connected from the portable memory to the recorder, an automatic data transfer takes place. As each 16K bytes of memory is transferred, the count displayed by the LEDS on the portable memory is incremented in a binary fashion. When the data transfer is complete, all eight of the LEDS will be turned on.

## 3.0 PHASE I - BREADBOARD UNIT

### 3.1 Work Statement

The following work was completed as Phase I of the project.

3.1.1 Work plan, activity schedule, cash flow projection, project management control and documentation procedures for the first phase of the project.

3.1.2 Final performance specifications in consultation with representatives of TDC and the railways. (See Appendix A).

3.1.3 Design of the breadboard unit components incorporating most features of the performance specifications obtained in previous task and/or provided by TDC. Establish production unit cost targets.

3.1.4 Fabrication of the following system components:

- One recording unit (72 V.D.C., approx. size 16" X 16" X 9" , weight 25 lbs.)
- One keyboard and control unit (110 V.A.C. fixed location)
- One portable memory unit (approx. size 10" X 15" X 6" , weight 7 lbs.)
- One 9" monitoring system (system testing).

3.1.5 Purchase of the following system components:

- One Printer unit
- Several sensor units not existing in the test locomotive. Made set of sensor units available to CP Rail.

3.1.6 Functional testing in laboratory of TDRS components to verify operation.

3.1.7 Installation supervision of system components, including sensors in a locomotive, in cooperation with CP Rail personnel for test demonstration purposes.

3.1.8 Monitor and support preliminary field test demonstration performed by CP staff. Maintain a 35 mm colour slide record of system components during field installation and test trial.

3.1.9 Purchase of ten sets of sensors for Phase II of the project.

3.1.10 Milestone report of Phase I including descriptive narrative, drawings, specifications, photographs of illustrations and supporting material in accordance with the reporting requirements detailed in Section 1.

3.1.11 Monthly progress reports.

### 3.2 Results

The following features are not included in the Phase I TDRS Breadboard System:

- Recording memory wrap around
- Extended location entry including Railroad and mileage
- Speed checks in the playback system
- Multiple recording storage in the Portable Memory

Investigations indicated the recorder could be built in a smaller assembly, similar to the portable memory unit.

### 3.3 Recommendations

In an effort to save space the recorder unit should be mounted in a much smaller assembly, similar to the portable memory unit. This will be accomplished in Phase II of the program.

## 4.0 PHASE II PROTOTYPE UNITS

### 4.1 Work Statement

The following work was completed as Phase II of the project.

4.1.1 Work plan, activity schedule, cash flow projection, project management control and documentation procedures.

4.1.2 Redesign of the breadboard recorder

The prototype units are easier to service and have only two «quick disconnect» connectors to bring the locomotive signals in. The recorder is shock mounted to a mounting plate which is attached to the mounting base by two wing nuts. The mounting base is wired to a junction box to which all the locomotive signals are brought in.

4.1.3 Fabrication of the following system components

- Six prototype recorders, each complete with mounting base and junction box. Three recorders are equipped with a non-volatile memory. (74 V.D.C. nominal).
- Two portable memory units (110 V.A.C./BATTERY operation).
- Two playback systems, each including a keyboard and a printer (110 V.A.C.).

4.1.4 Purchase of 10 miniature pressure switches, 10 thermostats.

4.1.5 Delivery and support of the following equipment to Warnlock Hershey for use in environmental testing:

- One recording unit complete with non-volatile memory, mounting base and signal simulator.
- One portable memory unit.
- One playback system complete with printer, keyboard, CRT monitor and dual disk drives.
- All the associated interconnect cables for the equipment listed above.

4.1.6 Installation supervision was provided for a prototype unit and then it was checked out to verify its operation.

4.1.7 A field trip was carried out on a round trip between Montreal and Toronto. A subsequent modification was made to the recording algorithm. No resets were observed, the clock did not stop and the time and date were correct during the trip.

4.1.8 Monthly progress reports.

4.1.9 Final report including descriptive narrative, drawings, specifications, photographs and supporting material.

4.1.10 Developed a non-volatile memory for recording the last minutes before a crash.

4.1.11 Developed software to display the present status of the recorder on the portable keyboard. The software supports a total of 35 input/output commands from the portable keyboard.

4.1.12 The following signals were deleted from the Phase I recorder software.

- pneumatic cutout (ON/OFF)
- engine run valve (ON/OFF)
- dynamic brake (analogue)
- direction (ON/OFF)

4.1.13 The following signals were added to the Phase II recorder software:

- vigilance (ON/OFF)
- leading/trailing (ON/OFF)
- forward (ON/OFF)
- reverse (ON/OFF)
- Bell (ON/OFF)
- dynamic brake (ON/OFF)

4.1.14 The display on the CRT was modified to support all the changes in 4.1.12 and 4.1.13. In addition the fan which was turned ON and OFF by the microprocessor, is now controlled by a mechanical thermostat. The temperature sensor was removed and the temperature reading deleted from the CRT display. The unused horsepower display on the CRT was also deleted.

4.1.15 A traction motor current shunt module was developed and is currently being used instead of the hall effect sensor. This new module cuts down on installation costs for the railway company.

4.1.16 Three features were added to an existing module. They are:

- An automatic reset when the power is turned on. This feature eliminates the need for manually depressing the reset button to start up the recorder.
- An automatic reset of the recorder, if any of the following occurs:

- Any circuit board in the system fails to respond within a few thousandths of a second.
- The program tries to access a non-existent memory location or a non-existent input/output device.
- A transient voltage spike upsets the recorder.

- A battery recharge circuit was added for use in the portable memory unit.

4.2 Results

4.2.1 One prototype recorder which was installed on a C.P. locomotive has been running for over two months without having to be serviced. The data is transferred whenever the locomotive comes back to its «base». A typical recording is approximately one thousand miles. Excerpts from a typical run are given in Appendix D.

4.3 Recommendations

4.3.1 Hardware

i) The portable memory enclosed in its transit case is heavy and cumbersome. A lighter and much more compact unit should be purchased or developed.

ii) Station identification or mileage markers should be input to the recorder automatically so that the train location can be pinpointed. This would also permit the automatic calibration of the wheel diameter.

iii) If the memory capacity is insufficient, it can be increased to 8 times its present size (i.e. approximately 8,000 miles capacity).

iv) An impulse detection device such as an accelerometer should be installed in order to detect when a crash occurs.

v) The possibility of combining the junction box with the recorder mounting base should be investigated.

4.3.2 Software

i) The speed should not be recorded if there is a change of one mile per hour while the train is going 20 m.p.h. or faster. This would prevent a lot of redundant velocities from being recorded if the speed is fluctuating between two values.

ii) If the playback system comes across a series of four minute markers in which no signals have changed value, then the playback system should suppress the displaying of this time interval.

iii) The playback system should not put a header up until the first line of information to be displayed or printed is found.

iv) When the recorder unit is put into the playback mode, and then put back into the record mode, the present status of all the signals should be displayed on the CRT.

v) The playback software which displays exceptions should have the capability of concatenating commands. Details can be found in Appendix B - TDRS User's Manual.

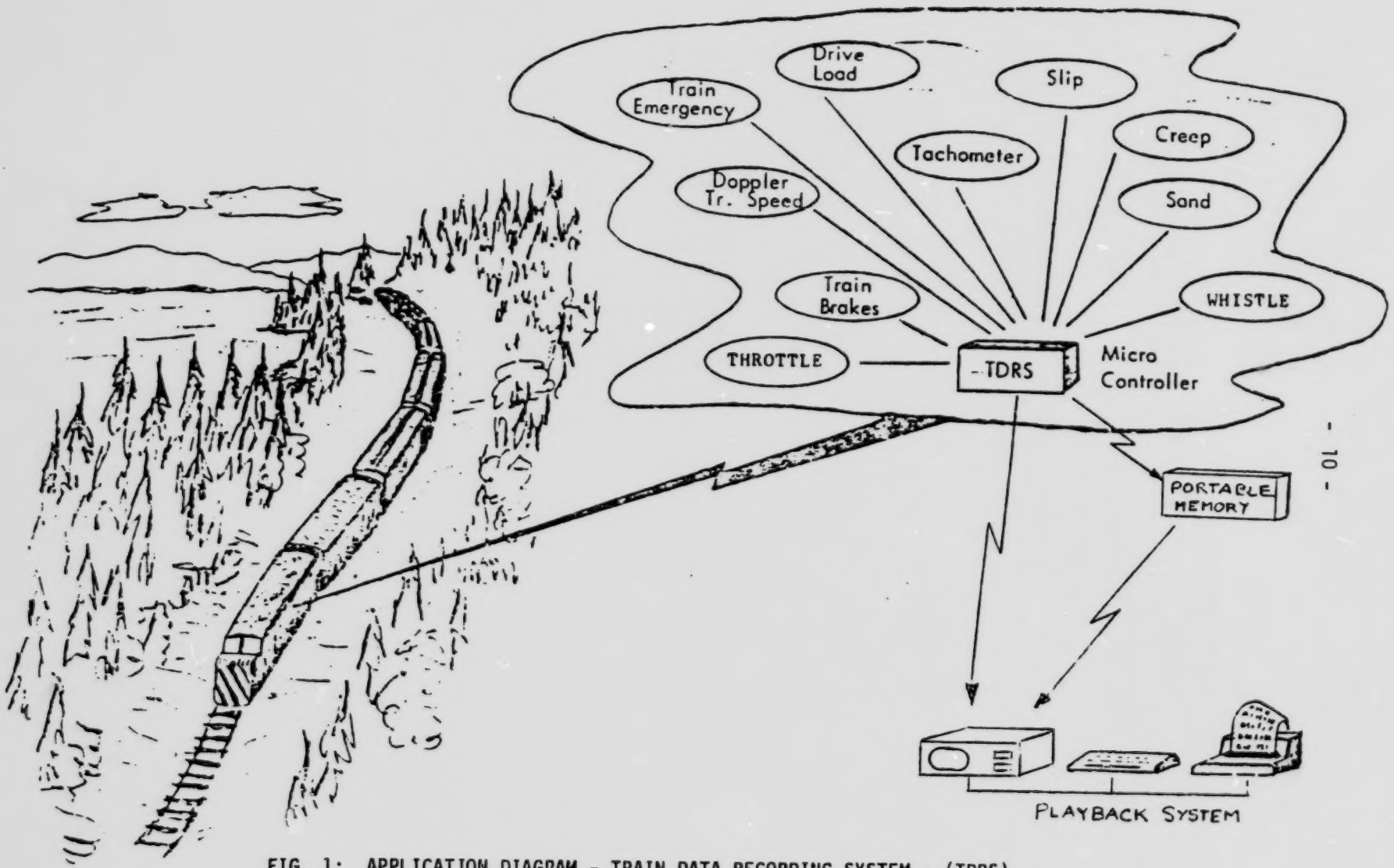
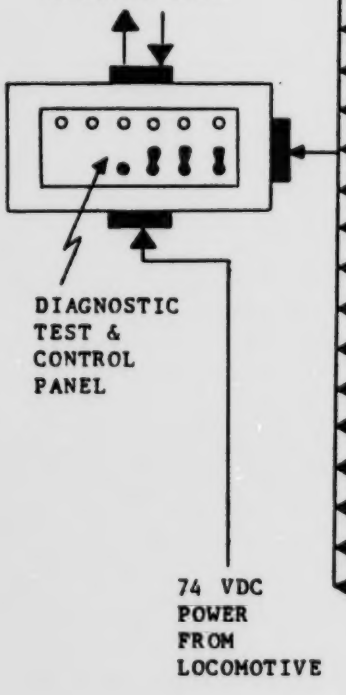



FIG. 1: APPLICATION DIAGRAM - TRAIN DATA RECORDING SYSTEM - (TDRS)




| PARAMETER | TYPE | RECORDER TYPE BASIC | OPTION 1 | OPTION 2 |
|---|---|---|---|---|
| 1. TIME (REAL AND ELAPSED) | RG | X | X | X |
| 2. SPEED | PT | X | X | X |
| 3. THROTTLE LEVEL | C | X | X | X |
| 4. DYNAMIC BRAKE | D | X | X | X |
| 5. BRAKE PIPE | A | X | X | X |
| 6. INDEP. BRAKE | A | X | X | X |
| 7. LOC. INIT. EMERG. | D | X | X | X |
| 8. LD. UNIT PWR RED | D | X | X | X |
| 9. SANDING | D | X | X | |
| 10. WHISTLE | D | X | X | X |
| 11. VIGILANCE | D | X | X | |
| 12. LEADING/TRAILING | CM | X | X | |
| 13. DISTANCE | PT | X | X | |
| 14. TRACTION CURRENT | A | X | X | |
| 15. WHEEL SLIP/CREEP | D | X | X | |
| 16. BELL | D | X | X | |
| 17. LOSS OF CONTIN. (LOCO) | D | X | | X |
| 18. SYSTEM POWER (LOCO) | D | X | | X |
| 19. MU MODE (LOCO) | D | X | | X |
| 20. INDEP. BRAKE (LOCO) | D | X | | X |
| 21. 10 KHZ CLOCK (LOCO) | D | X | | X |
| 22. PENALTY BRK (LOCO) | D | X | | X |
| 23. AUTO BRK (LOCO) | D | X | | X |
| 24. EQUAL. RESERV. | A | X | | X |
| 25. FORWARD | D | X | X | X |
| 26. REVERSE | D | X | X | X |

TYPE A EVENT = ANALOGUE MEASUREMENT
TYPE D EVENT = DIGITAL (ON/OFF) MEASUREMENT
TYPE C EVENT = CODED DATA
TYPE CM EVENT = CODED MESSAGE
TYPE PT EVENT = PULSE TRAIN
TYPE RG = RECORDER GENERATED VALUE

FIGURE 2 - LIST OF TRAIN OPERATING PARAMETERS

GM LOCOMOTIVE CONNECTION POINTS

| | SIGNALS | | |
|---|---|---|---|
| BTN1 | 74 VDC NEG | 1 | 2 |
| BTP1 | 74 VDC | | |
| | +15 VDC | 3 | 3 |
| | VIGILANCE | 4 | 4 |
| | ±15 VDC COMMON | 5 | 5 |
| TERMINAL B | TACHOMETER COMMON | 6 | 7 |
| TERMINAL 12 | TACHOMETER SIGNAL | | |
| | BRAKE PIPE PRESSURE | 8 | 9 |
| | EQUALIZING RESERVOIR PRESSURE | | |
| | INDEPENDANT BRAKE CYLINDER PRESSURE | 10 | 11 |
| | TRACTION MOTOR CURRENT | | |
| MR RELAY | DF VALVE | 12 | 12 |
| 21T | DYNAMIC BRAKE | 13 | 13 |
| | LOCOMOTIVE INITIATED EMERGENCY | 14 | 14 |
| | WHISTLE | 15 | 15 |
| TERMINAL 31NG | A VALVE | 16 | 16 |
| TERMINAL 31N7 | B VALVE | 17 | 17 |
| TERMINAL 31N8 | C VALVE | 18 | 18 |
| TERMINAL 31N9 | D VALVE | 19 | 19 |
| WL RELAY 13WE | WHEEL SLIP | 20 | 20 |
| TERMINAL 31N11 | SANDING | 21 | 21 |
| TERMINAL 31N12 | LEAD UNIT POWER REDUCTION | 22 | 22 |
| | BELL | 23 | 23 |
| | +12V (TO WHISTLE AND LOCOINIT. EMERG) | 24 | 24 |
| | TRAINLINE W8 (FORWARD) | 25 | 25 |
| | TRAINLINE W9 (REVERSE) | 26 | 26 |
| | TRAINLINE W13R (LEAD/TRAIL) | 27 | 27 |
| | +12V (TO BELL) | 28 | 28 |
| | 10 KHZ CLOCK FAILURE | 29 | 29 |
| | PENALTY BRAKE APPLICATION | 30 | 30 |
| | 12 VDC NEG | 31 | 31 |
| | AUTO BRAKE RELEASE | 32 | 32 |
| | LOSS OF CONTINUITY | 33 | 33 |
| | SYSTEM POWER ON | 34 | 34 |
| | MU MODE | 35 | 35 |
| | INDEPENDANT MODE | 36 | 36 |

TB201

TB202

TB203

JUNCTION BOX

TB101

TB102

TB103

TDRS MOUNTING BASE

R1 = 3.9KΩ (2 WATTS)
CR1 = 12V 1 WATT ZENER

FIGURE 3

REVISIONS

REV 1 i) CHANGE TB201 #6 TO VIGILANCE AND TAPEALL WIRE
ii) CHANGE TB201 #12 FROM DIRECTION TO DF VALVE
iii) CHANGE TB203 #33 FROM LEAD/TRAIL TO OVERSPEED
iv) CHANGE TB203 #34 FROM FORWARD TO REVERSE
v) CHANGE TB203 #35 FROM REVERSE TO LEAD/TRAIL
vi) DELETE TB203 #31 VIGILANCE
vii) DIRECTION OF WIRE HAS BEEN CORRECTED ON TB203 #31
JUNE 6 1983 GG

REV 2 SUBSTITUTE:
i) TRAINLINE W8 FOR LOSS OF CONTINUITY
ii) TRAINLINE W9 FOR SYSTEM POWER ON
iii) TRAILINE W13R FOR MU MODE
iv) CHANGE INDEPENDANT MODE FROM TB203 #28 TO TB203 #36
JUNE 7 1983 GG

REV 3 i) ADD R1 AND CR1
JUNE 10 1983 GG

REV 4 i) ADD LOCO. SUPPL. SHIELD POWER TO TB201 # 24
SEPT 20 83 GG

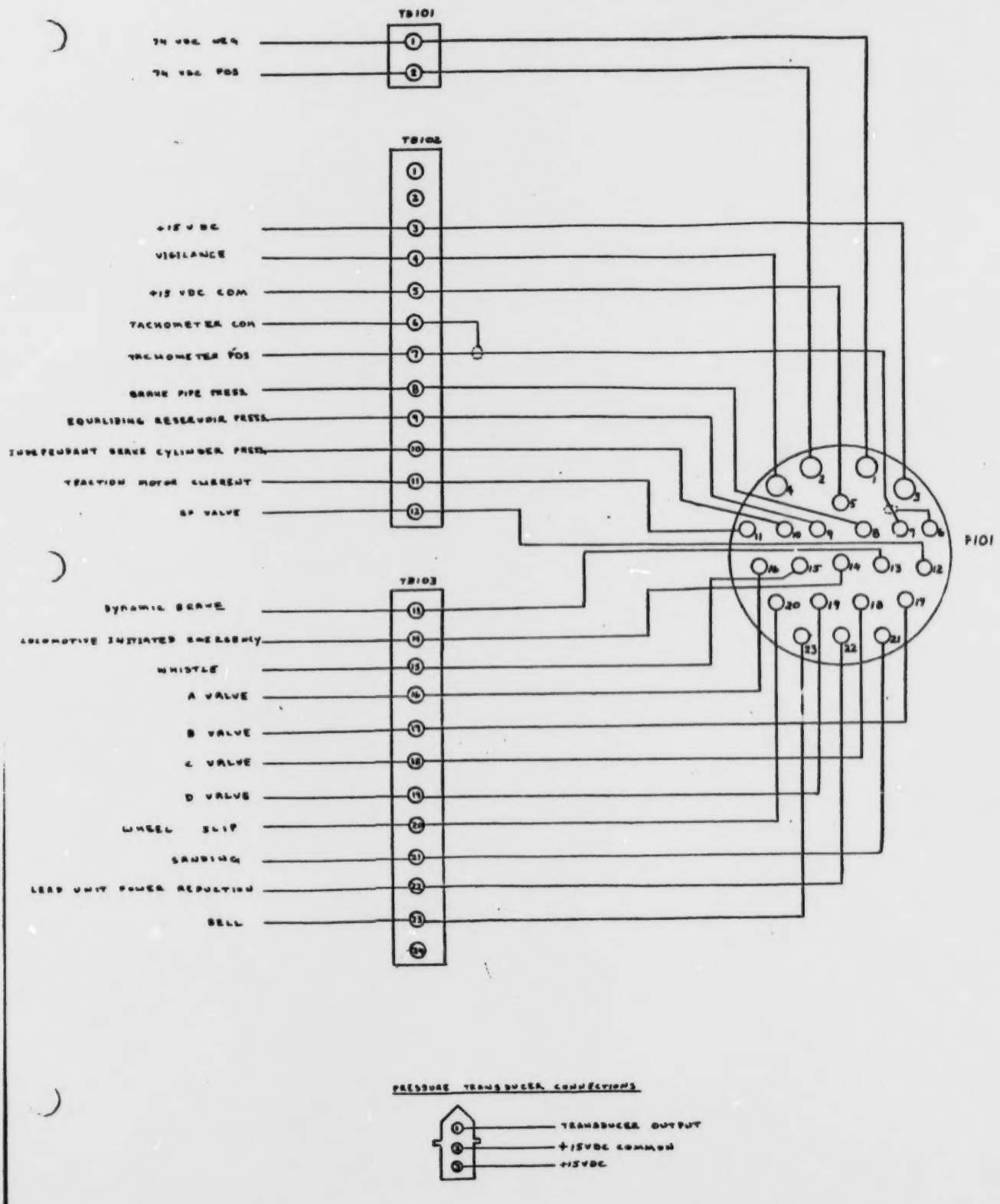
REV 5 i) USE SHIELDED CABLE FOR TACH SIGNAL
OCT 19 83 GG

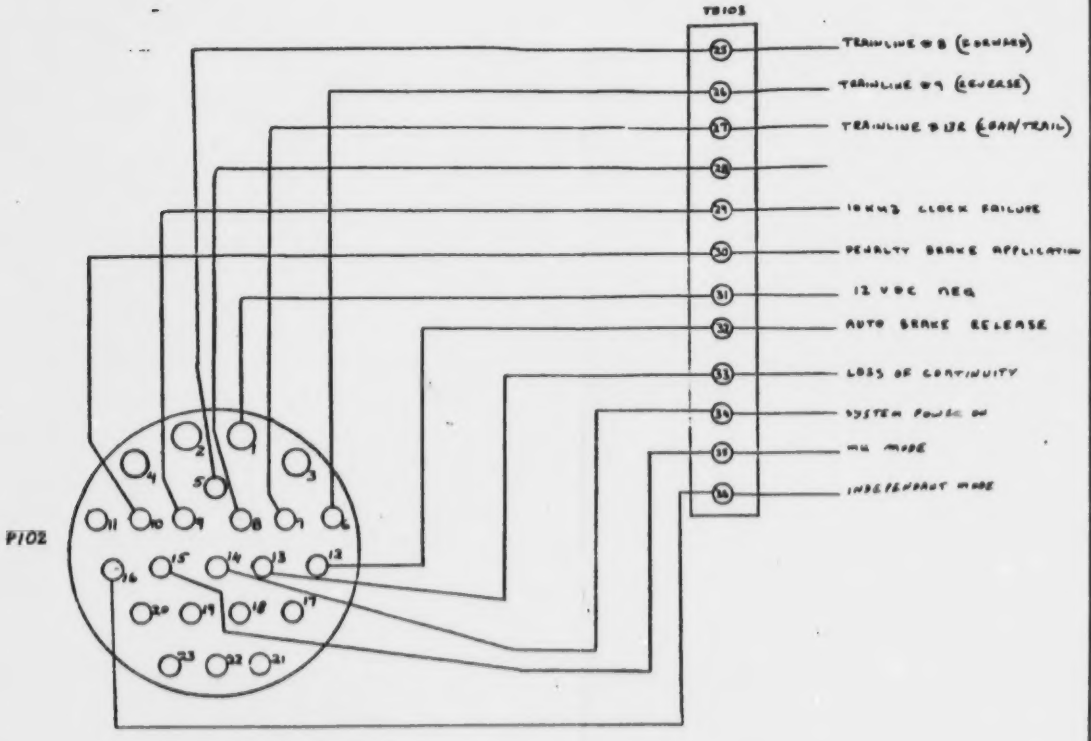
DRWN / DESS G. GUEVARA
CHK'D / VER
DATE MARCH 14 83

MPB TECHNOLOGIES INC.

TITLE / TITRE PHASE II
JUNCTION BOX / MOUNTING BASE WIRING DIAGRAM

D


TB101
74 VDC NEG
74 VDC POS
TB102
+15 V DC
VIGILANCE
+15 VDC COM
TACHOMETER COM
TACHOMETER POS
BRAKE PIPE PRESS.
EQUALIZING RESERVOIR PRESS.
INDEPENDANT BRAKE CYLINDER PRESS.
TRACTION MOTOR CURRENT
SP VALVE
TB103
DYNAMIC BRAKE
LOCOMOTIVE INITIATED EMERGENCY
WHISTLE
A VALVE
B VALVE
C VALVE
D VALVE
WHEEL SLIP
SANDING
LEAD UNIT POWER REDUCTION
BELL
P101
PRESSURE TRANSDUCER CONNECTIONS
TRANSDUCER OUTPUT
+15VDC COMMON
+15VDC




REVISIONS

REV) i) CHANGE SIGNAL ON TB103 (35) FROM DIRECTION TO GO VALVE

ii) CHANGE LOSS OF CONTINUITY SIGNAL FROM PIN 15 TO PIN 5

iii) ADD SIGNALS FOR DIRECTION SENSING ON 9234/35

iv) ELIMINATE NEON SHORTS AND REPLACE WITH DIODE SIGNAL PINS. MAY 25 1983 J.L. JC

REV2 SUBSTITUTE
i) TRAINLINE #8 FOR LOSS OF CONTINUITY
ii) TRAINLINE #12 FOR SYSTEM POWER ON
iii) TRAINLINE #12 FOR MU MODE
iv) CHANGE INDEPENDANT MODE FROM TB103 #28 TO TB103 #36
JUNE 7 1983 GG

FIGURE 4

| | |
|---|---|
| DRWN / DESS G. GUEVARA | MPB TECHNOLOGIES INC. |
| CHD / VER DEC 22 1982 DATE | |
| | TITLE / TITRE TERMINAL STRIP AND PLUG CONNECTIONS (PAGE 36) |

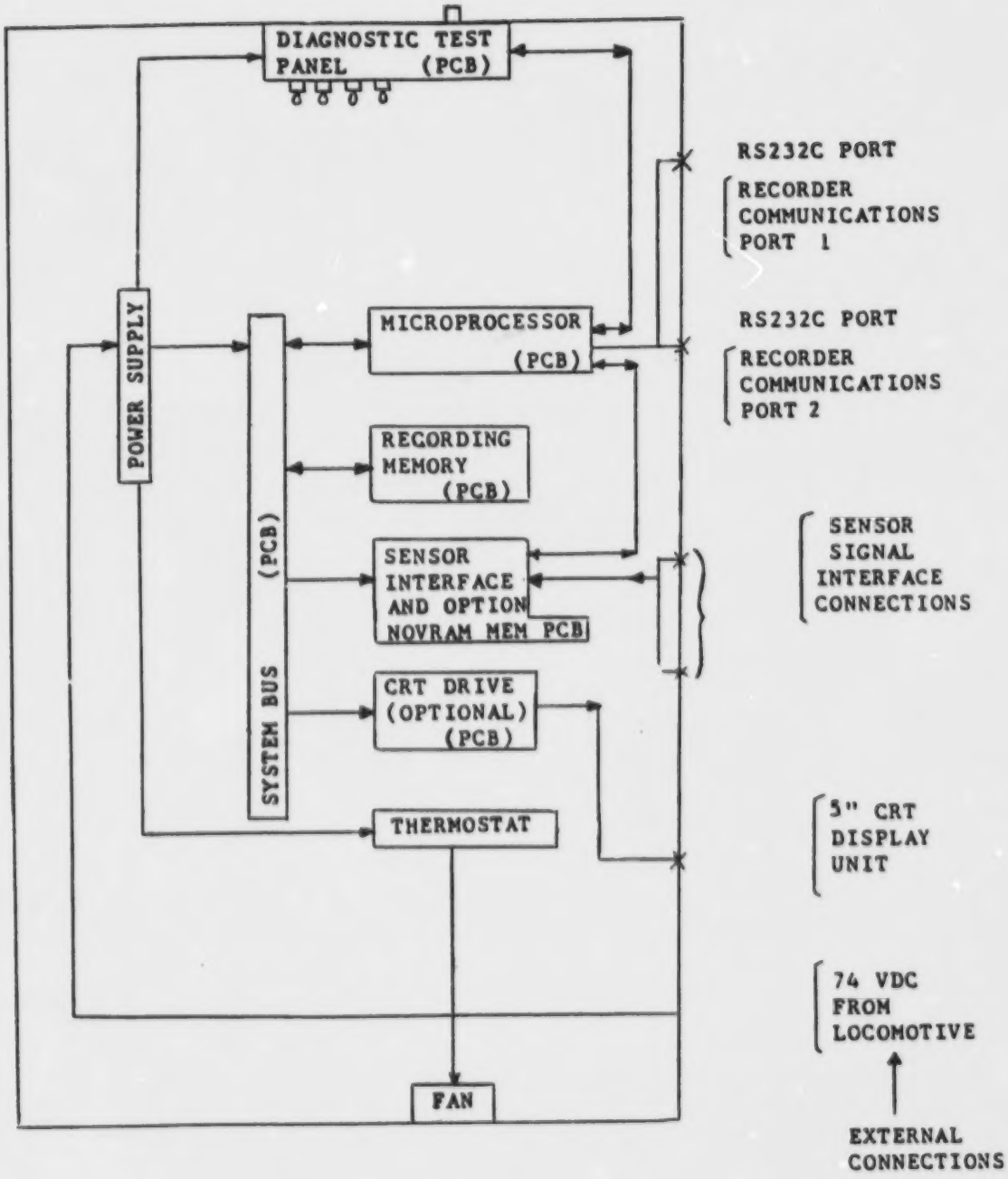



FIGURE 5 - TDRS RECORDER BLOCK DIAGRAM

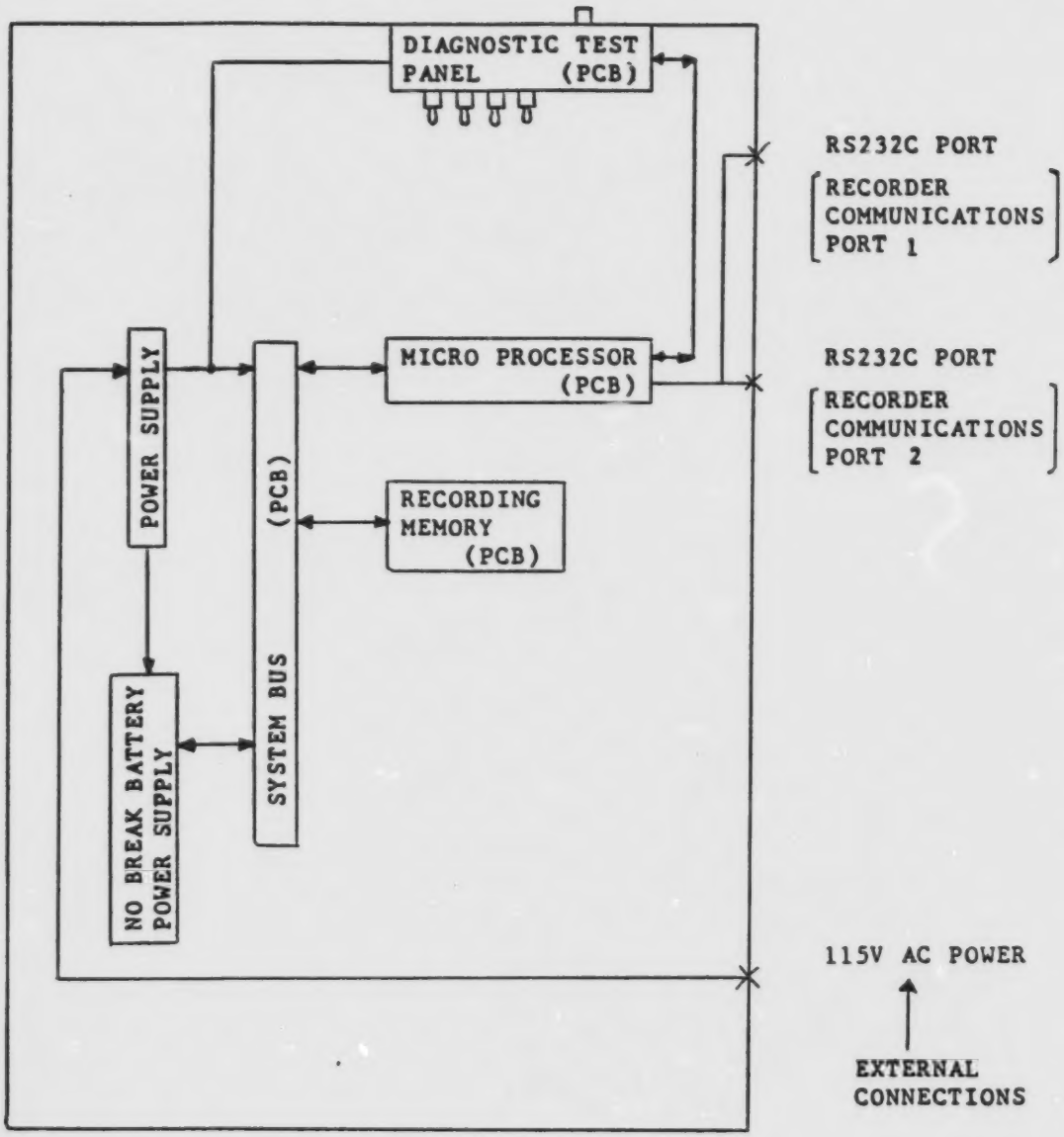



FIGURE 6 - TDRS PORTABLE MEMORY BLOCK DIAGRAM

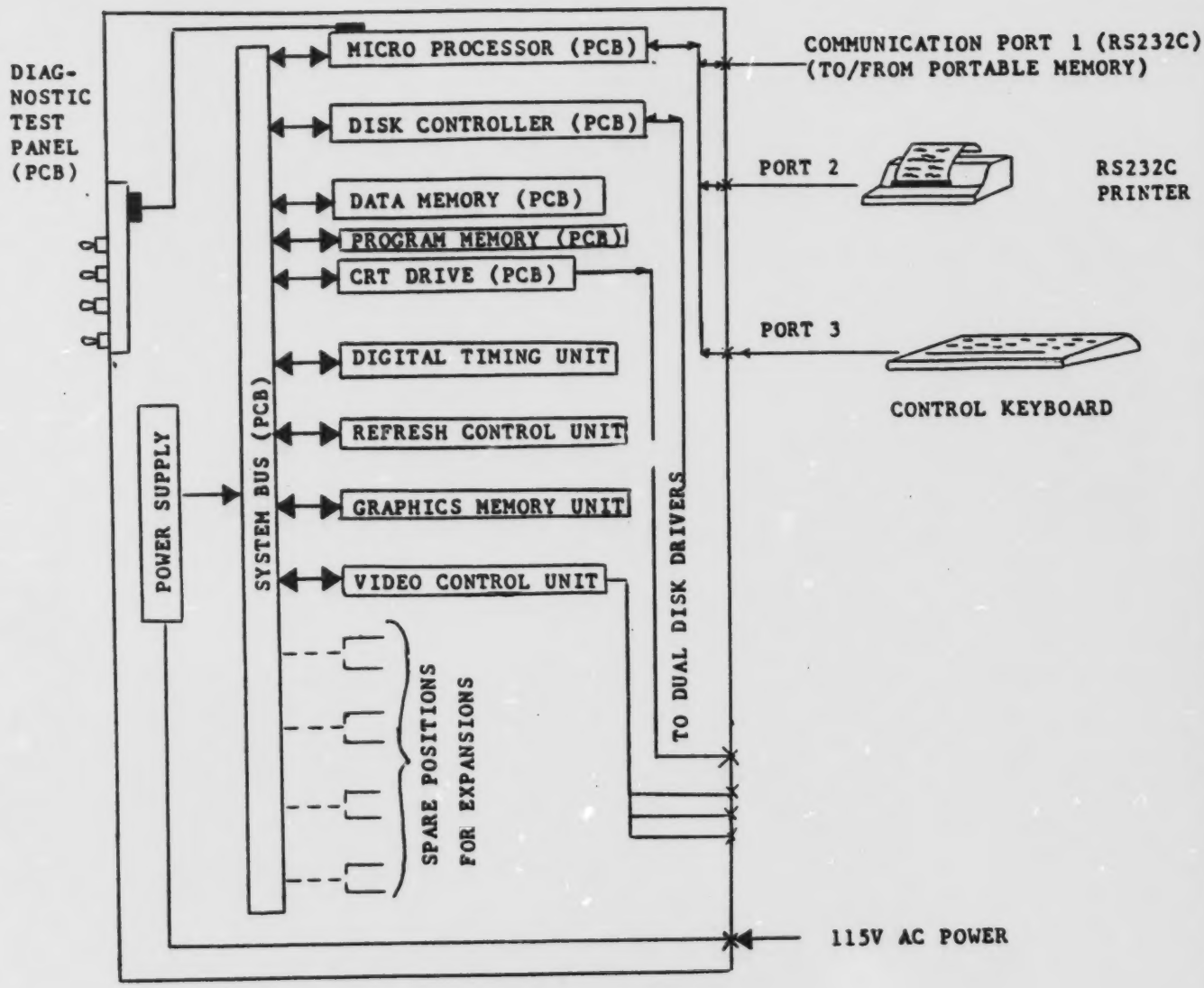
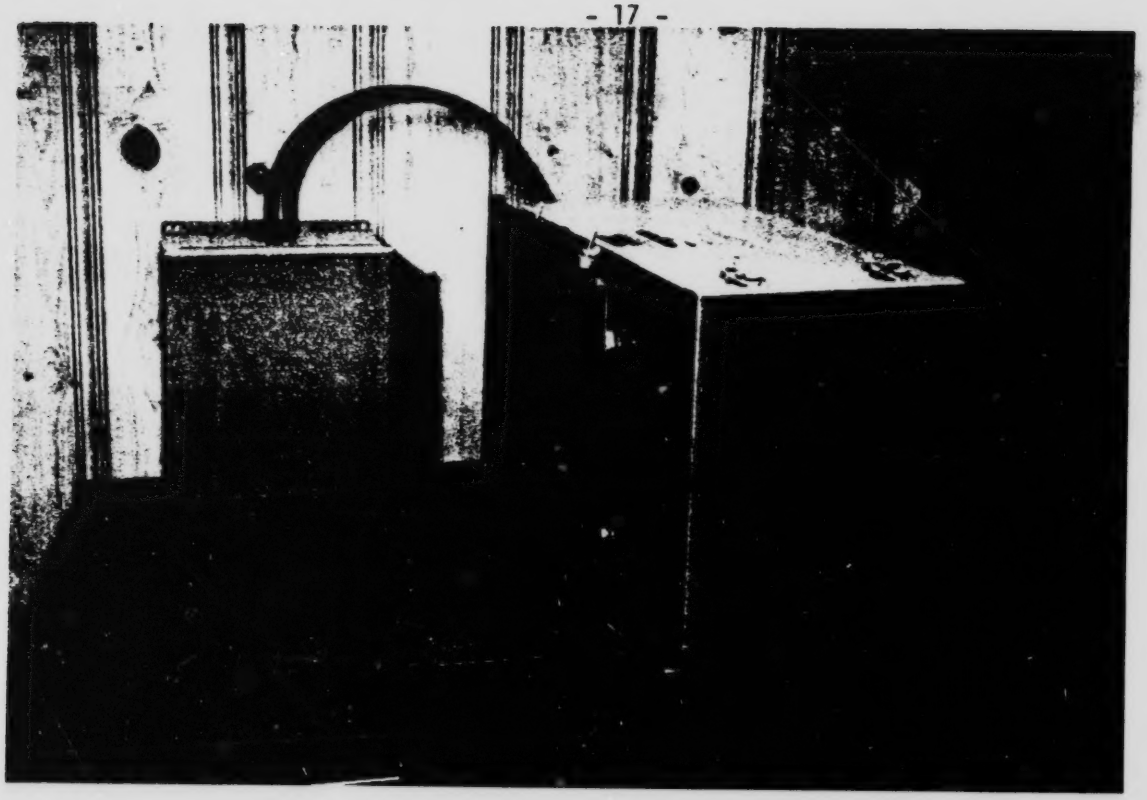
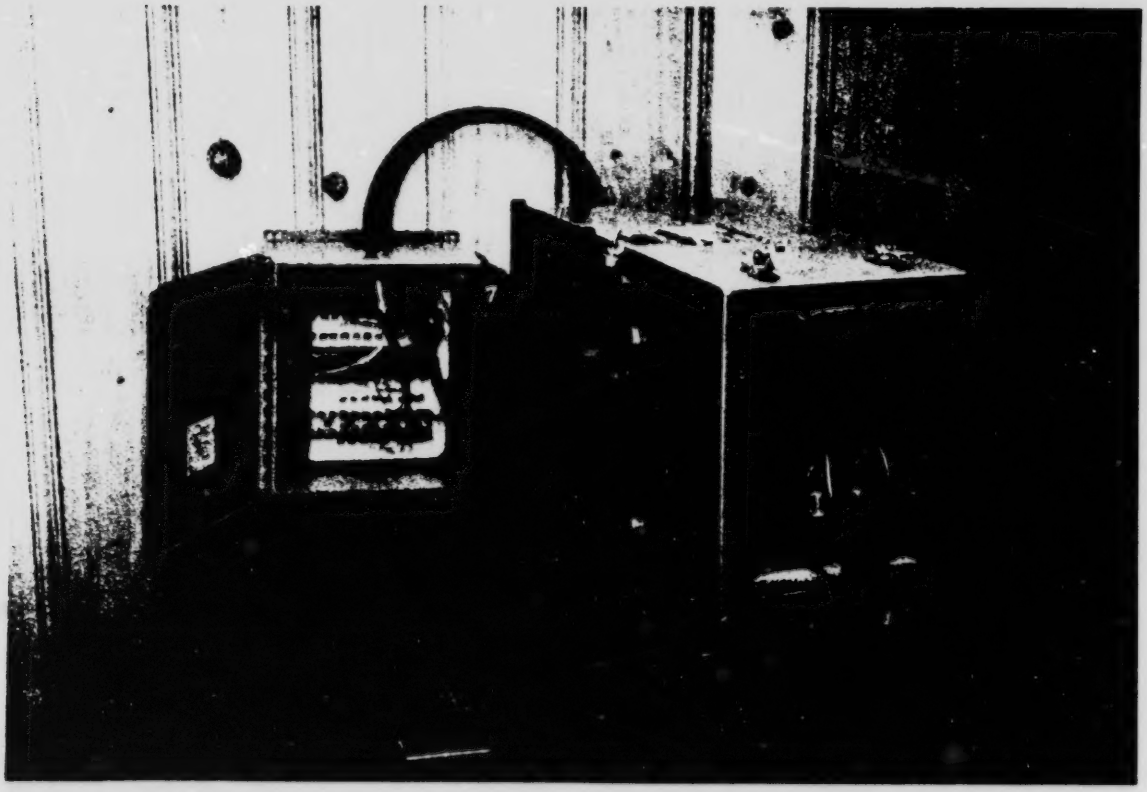



FIGURE 7 - TDRS PLAYBACK UNIT BLOCK DIAGRAM

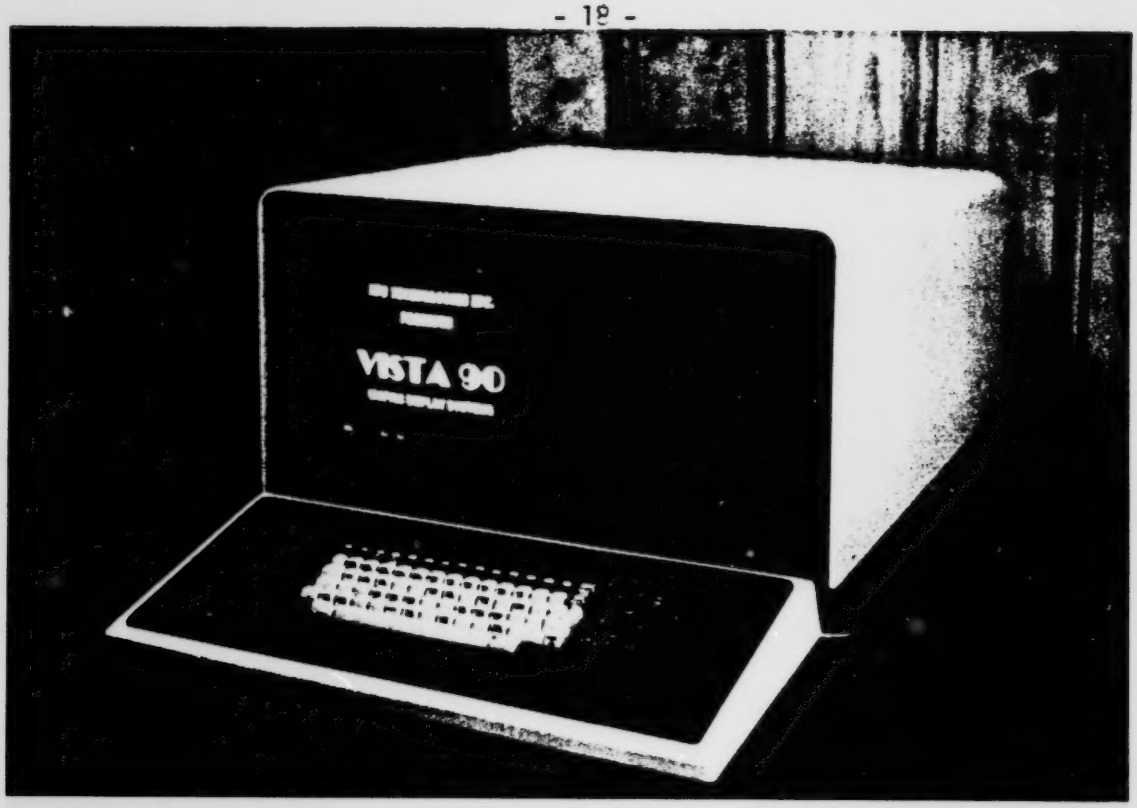


Recorder (in environmental shroud) and Junction Box

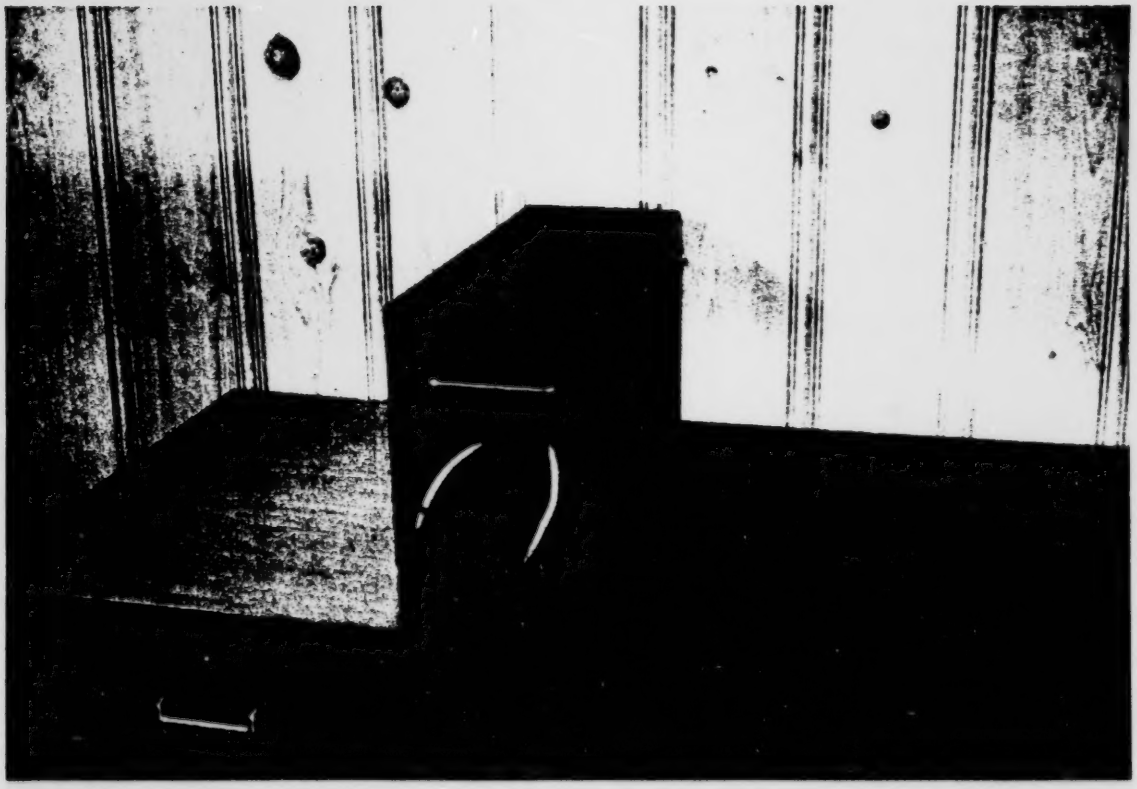


Same as above but with front panel removed and junction box door open

FIGURE 8 - EQUIPMENT PHOTOGRAPHS




Playback Unit



Portable Memory Unit

FIGURE 9 - Equipment Photographs

# APPENDIX A

# TDRS SPECIFICATION

# SPECIFICATION FOR A

# LOCOMOTIVE EVENT RECORDING SYSTEM

# SPECIFICATION FOR A LOCOMOTIVE EVENT RECORDING SYSTEM

## TABLE OF CONTENTS


1. INTRODUCTION

2. GENERAL CONDITIONS

3. DESCRIPTION OF EQUIPMENT

4. RECORDING REQUIREMENTS

5. OUTPUT EQUIPMENT AND FORMAT

6. INTERCONNECTION WITH OTHER SYSTEMS

7. HARDWARE SPECIFICATIONS

## 1.0 SCOPE

1.1

This specification covers the supply of equipment and supervision of installation for a locomotive event recorder and playback system for diesel-electric locomotives to be furnished by the vendor.

The purpose of the equipment shall be to:

a) record basic locomotive operating parameters as a «crash recorder»

b) record, in addition to (a), certain operating parameters useful for display to engineman of end-of-train condition and current value of acceleration or deceleration, crew education, discipline and investigations

c) record, in addition to (a), certain operating parameters required to monitor operation of «Locotrol». «Locotrol» is a system for controlling, by radio, unmanned mid-train locomotives

## 2.0 GENERAL CONDITIONS

2.1

Design, equipment, material and workmanship shall be of consistent high quality. All electrical equipment shall conform to CSA standards where applicable.

2.2

The Vendor shall purchase all material and supplies required for this system from Canadian manufacturers if such materials and supplies of suitable quality are procurable in Canada upon terms as favourable as elsewhere.

2.3

The Railway or locomotive manufacturer shall perform the installation of all equipment according to the Vendor's detailed instructions. The Vendor shall inspect and approve all work performed by the Railway as it is completed.

2.4

The Vendor shall provide the services of an engineer or technical personnel, as required, for testing each complete system installation. Installation testing of each system shall be carried out at the site(s) specified in the call for tender document.

2.5

Nominal supply voltage shall be 74 volts DC ungrounded. Estimated regulation shall be plus 10 percent and minus 30 percent. The current requirement for the recorder shall be typically about 1 amp.

2.6

All locomotive mounted equipment shall be suitable for operating in unheated areas on locomotives over any ambient temperature range of minus 40 to plus 70 degrees celsius and over any humidity range of 0 to 100 percent, non-condensing without requiring any adjustment. Playback equipment normally located in an office environment shall be suitable for use over any ambient temperature range of 0 to plus 40 degrees celsius and any humidity range of 0 to 100 percent non-condensing without requiring any adjustment.

2.7

Locomotive speed shall be obtained from a railway supplied axle generator with an output frequency of 60 pulses for each wheel revolution for a standard 39 inch diameter wheel. Wheel diameter shall be subject to change due to wheel wear.

2.8

System control shall be performed by microprocessor technology and shall be designed to be easily added to or altered without undue disruption.

2.9

The system shall be designed to be immune to electromagnetic interference from external sources which can be encountered in the railway environment.

2.10 Maintenance

The system shall use high reliability components to keep maintenance to a minimum and shall be designed to facilitate ease of maintenance and service. The replacement of any component can be performed in a straightforward manner and with a minimum of disruption of adjacent components.

## 3.0 DESCRIPTION OF EQUIPMENT

### 3.1 Recorder Unit

#### 3.1.1 Recorder Hardware

The Recorder Unit shall be comprised of a microprocessor based controller connected to a series of analogue and digital signal sensors as shown in Figure 1. The controller shall be housed in a unit assembly designed to protect the electronics from a harsh mechanical, electrical and thermal environment.

Salient features of the Recording System Controller shall be as follows:

- Program Memory Capacity - 64K Bytes
- RS232C Interface Ports - 2
- Analogue Interface Ports - 4 Inputs (Expandable to 16 Inputs)
  - 0 Outputs (Expandable to 8 Outputs)
- Digital Interface Ports - 24 Inputs (Expandable to 32 Inputs)
- Self Testing Diagnostics

#### 3.1.2 Recorder Software

The recorder unit shall be programmed to scan and monitor all the sensor signals listed in Figure 1. A recording shall be made whenever a digital type of eventchanges status, or when one of the analogue event changes by a specified amount.

The recorder shall be capable of being interrogated by a portable keyboard connected to the Serial RS232C Port 2. The recorder shall output to the keyboard the present status of the parameter that was asked for.

The recording shall provide for a printout of real time together with speed and distance and all the signals being recorded.

A simple flow chart of the monitoring and recording software system is shown in Figure 3.

### 3.2 Playback Unit

#### 3.2.1 Playback Unit Hardware

The Playback System shown in Figure 2 shall be comprised of the following equipment:

a) Playback Controller Unit

b) Control Key Set

c) Hardcopy Printer (optional)

The Controller Unit shall be housed in a unit assembly containing one or two floppy disk drives and a color monitor. A block diagram of the Controller Unit interfaced with the peripheral equipment is shown in Figure 2.

The CRT readout shall be provided for rapid data scanning and analysis before printout.

3.2.2 Playback Software

The Playback System shall be programmed to provide the following:

a) Receive the data recording from the portable memory unit via the RS232C interface port and store it on diskette;

b) Printout the status of all recorded functions or calculated functions on each line of output. Digital events shall be shown as '0' if the function is OFF and as a '1' if the function is ON. Analogue parameters shall be shown as a direct analog reading of the function;

c) The beginning of each page of the printout shall contain the column headings. The format of the columns, from left to right shall be distance, time, speed, throttle, analogue functions and digital functions;

d) Perform calculations to obtain distance;

e) Selectively output sections of the recorded information by outputting only the information that satisfies a certain condition entered by the control key set.

3.2.3 Playback System Test Diagnostics

The playback unit program shall include a complete set of hardware self test diagnostics which can be run by a service technician to isolate a fault.

Typical tests are as follows:

1) CPU Test - Exercises the micriprocessor logic a control/ display panel;

2) Key Set Test - provides a display of the Keyset codes;

3) ROM Memory Test - provides a check sum test and display;

4) RAM Memory Test - provides a series of memory fault diagnostic tests which pinpoint a fault to the chip level;

5) RS232C Interface Test - provides a test of the RS232 interface ports using a test connector;

6) Disk Drive Test - provides a series of disk drive tests with resultant LED display of fault status.

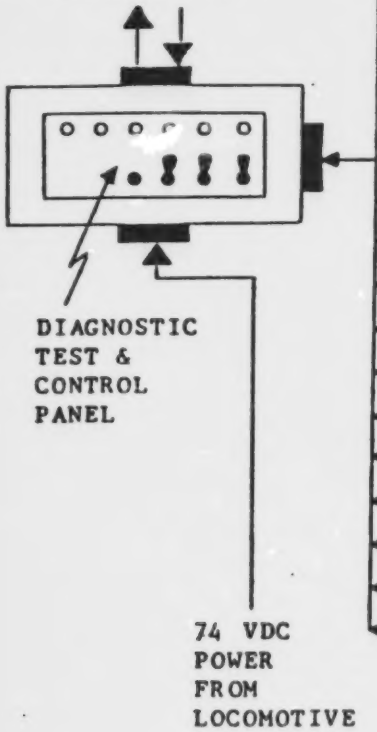
### 3.3.1 Mean Time Between Failure (MTBF)

The Recorder System shall use high reliability components to keep maintenance to a minimum. A MTBF of 15,000 hours shall be the design target. Shock mounts shall be used to minimize the effects of shock and vibration. Signal connections shall be made using qualified components.

### 3.3.2 Mean Time to Repair (MTTR)

The self testing diagnostics shall enable the service technician to isolate a faulty module or component in minimum time. A MTTR of 10 minutes shall be the design target and replacement of any printed circuit board or other device (power supply, etc.) shall be performed in a straight forward manner and with a minimum of disruption of adjacent components.

To prevent printed circuit damage it is recommended that faulty modules be returned to MPB Technologies Inc. for repair.




| PARAMETER | TYPE | RECORDER TYPE BASIC | OPTION 1 | OPTION 2 |
|---|---|---|---|---|
| 1. TIME (REAL AND ELAPSED) | RG | X | X | X |
| 2. SPEED | PT | X | X | X |
| 3. THROTTLE LEVEL | C | X | X | X |
| 4. DYNAMIC BRAKE | D | X | X | X |
| 5. BRAKE PIPE | A | X | X | X |
| 6. INDEP. BRAKE | A | X | X | X |
| 7. LOC. INIT. EMERG. | D | X | X | X |
| 8. LD. UNIT PWR RED | D | X | X | X |
| 9. SANDING | D | X | X | |
| 10. WHISTLE | D | X | X | X |
| 11. VIGILANCE | D | X | X | |
| 12. LEADING/TRAILING | D | X | X | |
| 13. DISTANCE | PT | X | X | |
| 14. TRACTION CURRENT | A | X | X | |
| 15. WHEEL SLIP/CREEP | D | X | X | |
| 16. BELL | D | X | X | |
| 17. LOSS OF CONTIN. (LOCO) | D | X | | X |
| 18. SYSTEM POWER (LOCO) | D | X | | X |
| 19. MU MODE (LOCO) | D | X | | X |
| 20. INDEP. BRAKE (LOCO) | D | X | | X |
| 21. 10 KHZ CLOCK (LOCO) | D | X | | X |
| 22. PENALTY BRK. (LOCO) | D | X | | X |
| 23. AUTO BRK (LOCO) | D | X | | X |
| 24. EQUAL. RESERV. | A | X | | X |
| 25. FORWARD | D | X | X | X |
| 26. REVERSE | D | X | X | X |

TYPE A EVENT = ANALOGUE MEASUREMENT
TYPE D EVENT = DIGITAL (ON/OFF) MEASUREMENT
TYPE C EVENT = CODED DATA
TYPE CM EVENT = CODED MESSAGE
TYPE PT EVENT = PULSE TRAIN
TYPE RG = RECORDER GENERATED VALUE

FIGURE 1 - LIST OF TRAIN OPERATING PARAMETERS

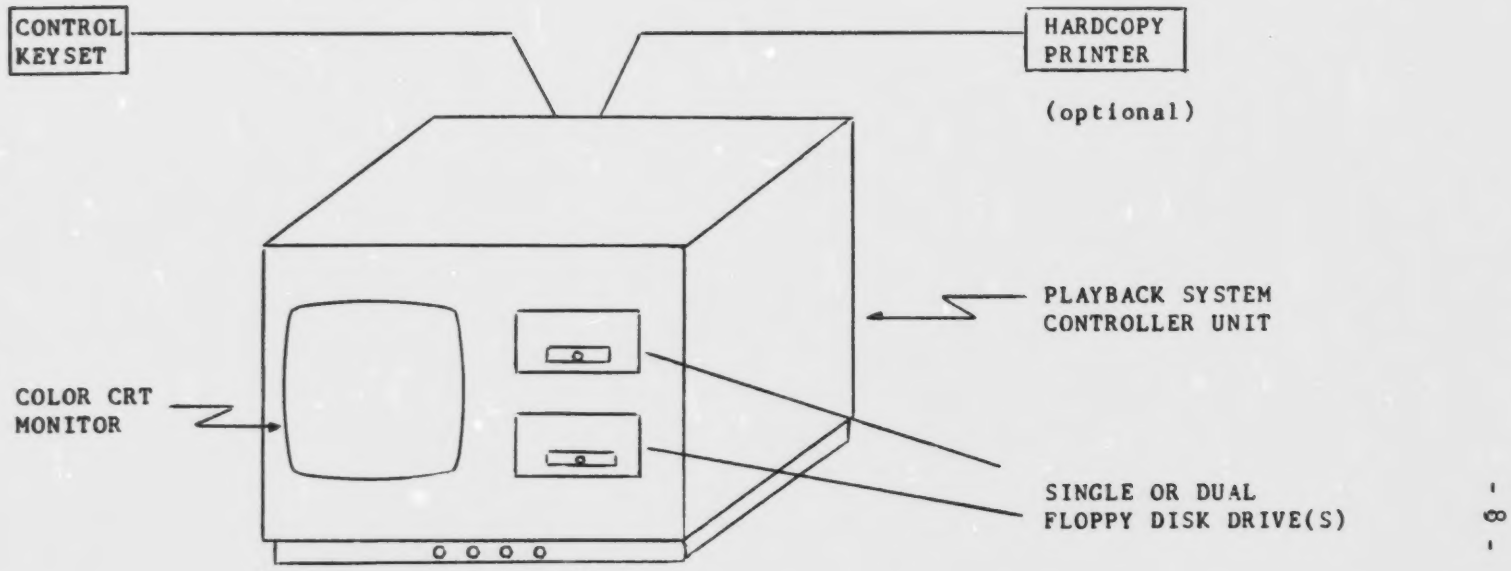



FIGURE 2 - PLAYBACK SYSTEM APPLICATION DIAGRAM

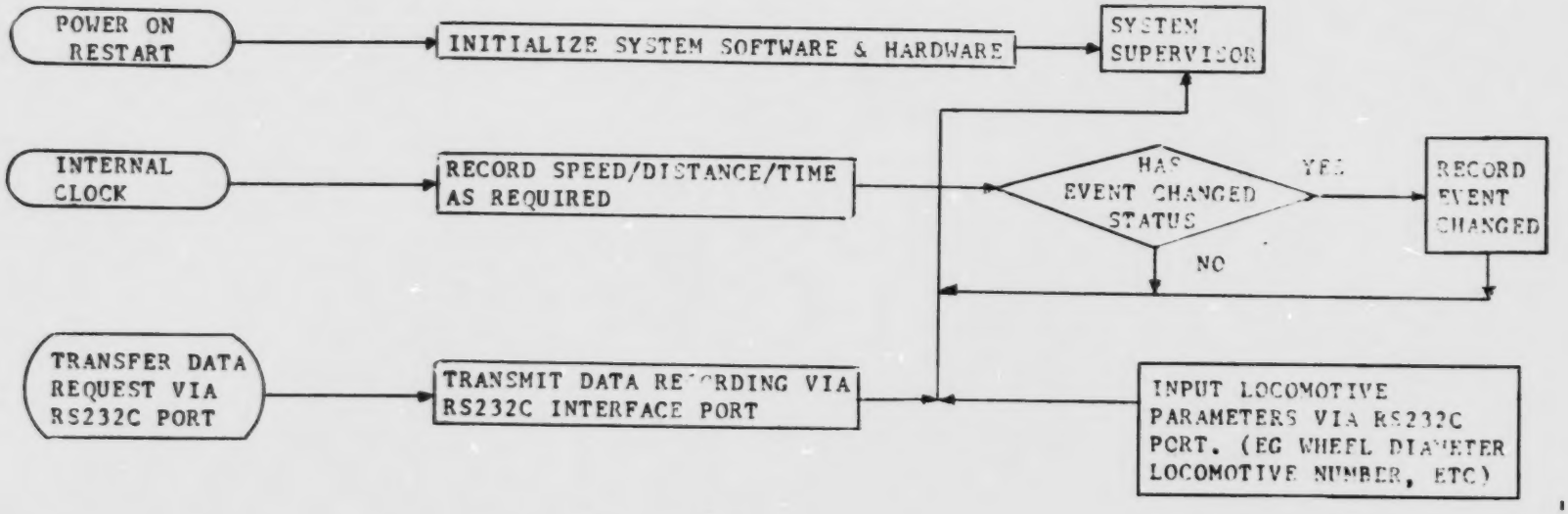

POWER ON RESTART
INITIALIZE SYSTEM SOFTWARE & HARDWARE
SYSTEM SUPERVISOR
INTERNAL CLOCK
RECORD SPEED/DISTANCE/TIME AS REQUIRED
HAS EVENT CHANGED STATUS
YES
RECORD EVENT CHANGED
NO
TRANSFER DATA REQUEST VIA RS232C PORT
TRANSMIT DATA RECORDING VIA RS232C INTERFACE PORT
INPUT LOCOMOTIVE PARAMETERS VIA RS232C PORT. (EG WHEEL DIAMETER LOCOMOTIVE NUMBER, ETC)

FIGURE 3 FLOW DIAGRAM - RECORDER PROGRAM

4.0 RECORDING REQUIREMENTS

4.1 The following parameters listed by option shall be sensed and recorded by the system:

| PARAMETERS TO BE RECORDED | TYPE | RECORDER TYPE BASIC | OPTION 1 | OPTION 2 |
|---|---|---|---|---|
| 1. TIME (REAL AND ELAPSED) | RG | X | X | X |
| 2. SPEED | PT | X | X | X |
| 3. THROTTLE LEVEL | C | X | X | X |
| 4. DYNAMIC BRAKE | D | X | X | X |
| 5. BRAKE PIPE PRESSURE | A | X | X | X |
| 6. INDEPENDENT BRAKE CYLINDER PRESSURE | A | X | X | X |
| 7. LOCOMOTIVE INITIATED EMERGENCY | D | X | X | X |
| 8. LEAD UNIT POWER REDUCTION | D | X | X | X |
| 9. SANDING | D | X | X | |
| 10. WHISTLE | D | X | X | X |
| 11. VIGILANCE | D | X | X | |
| 12. LEADING/TRAILING | CM | X | X | |
| 13. DISTANCE | PT | X | X | X |
| 14. TRACTION MOTOR CURRENT | A | X | X | |
| 15. WHEEL SLIP, CREEP | D | X | X | |
| 16. BELL | D | X | X | |
| 17. LOSS OF CONTINUITY (LOCOTROL) | D | X | | X |
| 18. SYSTEM POWER ON (LOCOTROL) | D | X | | X |
| 19. MU MODE (LOCOTROL) | D | X | | X |
| 20. INDEPENDENT MODE (LOCOTROL) | D | X | | X |
| 21. 10 KHz CLOCK FAILURE (LOCOTROL) | D | X | | X |

| | PARAMETERS TO BE RECORDED | TYPE | BASIC | OPTION 1 | OPTION 2 |
|---|---|---|---|---|---|
| 22. | PENALTY BRAKE APPLICATION (LOCOTROL) | D | X | | X |
| 23. | AUTO BRAKE RELEASE BUTTON (LOCOTROL) | D | X | | X |
| 24. | EQUALIZING RESERVOIR | A | X | | X |
| 25. | FORWARD | D | X | X | X |
| 26. | REVERSE | D | X | X | X |

A - Analog Measurement Required

D - Digital (ON/OFF) Measurement Required

C - Coded Data

CM - Coded Message

PT - Pulse Train

RG - Recorder Generated Value

4.2

The system shall sample all items in Paragraph 4.1 at least 10 times each second and makes a recording whenever a digital type of event changes status or when one of the following analog parameters changes:

4.2.1

Brake pipe pressure by plus or minus 2 psi.

4.2.2

Independent brake cylinder pressure by plus or minus 2 psi.

4.2.3

Traction motor current by plus or minus 16 amps.

4.2.4

Equalizing reservoir pressure by plus or minus 3 psi.

4.3

The system shall record time, speed and distance, whenever a recording is made.

4.4

The crash recorder memory shall record the last 5 minutes before the crash occurred, assuming that locomotive power is lost upon a crash.

The system memory shall be capable of recording for over two days and 1000 miles for the Option 1 recorder, under normal operating conditions.

If the recorder memory fills up, it shall wrap around and replace the oldest recording with the newest data.

4.5

The basic recorder shall be designed to be easily expanded to accept future additions of Option 1 or Option 2 features.

4.6

At the start of a TRAIN recording run the following data shall be entered by Keyset:

A) TRAIN NUMBER

B) LOCOMOTIVE NUMBER

C) REAL TIME

D) ZONE

E) DATE

F) WHEEL DIAMETER

G) STATION/SUBDIVISION NUMBER

H) MILEAGE

I) RAILROAD NUMBER

J) OPERATOR'S NUMBER

## 5.0 OUTPUT FORMAT AND PLAYBACK EQUIPMENT

5.1

The status of all recorded functions or calculated functions shall be indicated on each line of output. Digital events shall be shown as a " 0" if the function is off and as a " 1" if the function is on. If a digital event is off it will not be displayed if it is a trailing zero on that line. This scheme speeds up the hard copy printout of the recording. Analog parameters shall be shown as a direct analog reading of the function. The beginning of each page of output shall contain the column headings. The format of the columns, from left to right shall be distance, time, speed, throttle, analog functions and digital functions.

5.2

The system shall be provided with a portable memory that is used to transfer the contents of the recorder memory to the playback equipment.

5.3

The playback equipment shall have the capability to selectively output sections of the recorded information by any recorded parameter.

## 6.0 INTERCONNECTION WITH OTHER EQUIPMENT

6.1

The system shall provide for interconnecting the following:

| EQUIPMENT | PORT |
|---|---|
| PARALLEL KEYBOARD | 3 |
| PRINTER | 2 |
| PORTABLE KEYBOARD | 2 |
| PORTABLE MEMORY UNIT | 1 |

## 7.0 HARDWARE REQUIREMENTS

7.1

The recorder and portable memory unit shall be housed in environmental shrouds. The recorder shall be equipped with shock mounts to protect the enclosed contents when installed on locomotives and shall protect against the following environmental factors:

7.1.1

Vibration: 5G at 2 to 44 hertz, in any direction.

7.1.2

Shock: 20G for .015 seconds, in any direction.

7.2

Enclosures shall also protect against:

7.2.1

Electromagnetic interference (EMI) exceeding MIL-STD-461A susceptibility (conducted and radiated).

7.2.2

Contamination: Water, oil, dust, dirt, grit and any other contaminants and corrosives as may be found in the heavy Railway environment.

7.3

Enclosures shall be equipped with the following:

7.3.1

Air ventilators, as required, with replaceable dust filters that shall not be accessible from the tops or rear sides of enclosures.

7.3.2

An access cover for removal of the inner assembly. The access cover shall be attached to the enclosure by means of latching assemblies which can be individually padlocked for security reasons. Gasket material shall be used to provide a seal between the access cover and the enclosure.

7.3.3

A means to easily remove the enclosure from its mounting position for service replacement. The recorder shall easily be removed from the locomotive by removing the access panel and unscrewing the two 23-pin connectors. The access cover shall be replaced and the two wing nuts on the mounting base shall be undone. The recorder can then be carried away using the handle provided.

7.3.4

Connectors for interconnection with other system components and service devices. Critical signal connectors shall be keyed to prevent damage due to incorrect plug insertion.

7.3.5

Each unit shall carry the Vendor's name and serial number.

7.4

Enclosures shall not exceed 26 inches wide, 16 inches high and 12-1/2 inches deep.

7.5

All adjustable components shall be sealed to prevent any movement or change of setting.

7.6

All circuit boards, sensors, switches, etc., and their mounting positions shall be clearly and permanently labelled with its functional name.

7.7

Electronic circuit boards shall be housed in an IEEE 796 card cage. Card cages shall be provided with a means to maintain circuit boards in position.

7.7.1

Electronic circuit boards shall be made of glass epoxy, no less than 3/32 of an inch thick.

7.7.2

Potted circuits shall not be used.

7.7.3

All electronic circuit boards except the diagnostic test panel, traction motor current interface and the pre-regulator shall be plug-in type.

7.7.4

In order to permit possible future expansion, the card cage shall have space for approximately 25% more electronic circuit boards.

7.8

Wiring in enclosures shall be stranded and insulated.

7.9

All electronic components, connector switches, etc., shall be according to the applicable military specification where possible and practical.

7.10

Environmentally sealed switches shall be provided.

7.11

All ON/OFF inputs to the recorder shall be provided with circuit isolation of at least 3000 volts. This does not include power supply inputs, which are covered elsewhere.

7.12

All cabling between enclosures, power supply, sensors and other equipment shall be stranded, PVC insulated, rated at 600 volts.

7.13

After completion of each production run the first unit shall be environmentally tested as in Appendix 'C'.

7.14

System power supply shall convert the nominal 74 volt locomotive electrical supply, using a solid state switching type, into regulated usable system voltages.

7.15

System power supply shall have 20,000 volt transient protection. All inputs shall be protected with transient absorption Zeener diodes in the mounting base.

7.16

The diagnostic test panel circuit board shall have four indicator LEDS which indicate the presence of each of the regulated voltages.

7.17

The system shall be provided with a 2-pole circuit breaker for circuit protection and is mounted inside the equipment enclosure. Fuses shall not be used.

# APPENDIX B

# TDRS USER'S MANUAL

TDRS USER'S MANUAL

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| 3. | PLAYBACK SYSTEM | |
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| | 3.1 Operating Procedures | 3-1 |

# SECTION 1 - RECORDER UNIT

## 1.0 GENERAL DESCRIPTION

The Recorder Unit is designed for continuous 24 hour operation. Once the Recorder has been turned on as described in Section 1.1, it will operate unattended until it is turned off or until a power failure occurs.

The recorder unit can be equipped with two memory storage modules as follows:

a. Long term (1 to 3 days) event recording memory

b. Short term (10 - 20 minute) crash recording memory

During normal operation the recorder stores events in both memories. In the event of a power failure the crash recorder memory will retain its contents, providing a record of the final 10 to 20 minutes of locomotive operation before power was lost.

The recorder has three operating modes as follows:

Mode Ø - Stop Recording Mode

In this mode, the recorder is reading all the sensors (detailed in Fig. 1-3) and displaying the data if a CRT and display controller are connected.

Mode 1 - Recording Data Mode

In this mode, the recorder unit is reading all the sensors, displaying the data if the CRT is connected, and recording data changes in the solid state memory.

Mode 2 - Initialization Mode

In this mode, the recorder is reading all the sensors and displaying the data if a CRT is connected. This is the mode in which the recorder should be during initialization, calibration or performing diagnostics.

It represents a recorder with no valid data in the solid state memory. All parameters, where possible, are set to default values (i.e. - the wheel diameter is set to forty inches) if no new data is input.

Note that the recorder mode should be set to record stop before a memory dump is done to ensure no extra data is recorded during the dump. After the transfer is complete, the recorder can be set to the record mode with the appropriate keyboard command. Using an automated dump, record stop and start are done automatically.

## 1.1 Operating Procedures

### 1.1.1 Recorder Turn On

The recorder is turned on and operates in Mode 1 by activating the circuit breaker. Optionally, the recorder can also be restarted by depressing the reset switch (note that activating the reset button will not automatically put the recorder back into record initialize, if the recorder was previously in a different mode such as record stop or recording). Note that in order to start up the recorder, the front panel switches should be set so that the leftmost two switches are reset (down), and the rightmost two are set (up), yielding a binary code of 0011.

### 1.1.2 Operation Control

The recorder responds to a series of keyboard entry commands to initialize and control various functions. These commands include data entry for items such as time and zone, mode setting (such as initialize and stop recording), commands for memory dumps and commands for displaying internal data externally via a keyboard/printer or equivalent. This entry routine also leaves unused commands for future implementation. These commands have been grouped into five groups; escape 1 to escape 5 inclusive.

1.1.2.1 Escape 1 Commands

1.1.2.1.1 Real Date Entry

The data within the recorder can be set using this command. It is done with the following keyboard sequence -

[ESCAPE 1] Ø $Y_1$ $Y_2$. $M_1$ $M_2$. $D_1$ $D_2$.

where $Y_1$, $Y_2$ are the years digits

$M_1$, $M_2$ are the months digits

$D_1$, $D_2$ are the days digits

1.1.2.1.2 Time Zone Entry

The time zone entry is entered into the recorder with the following key sequence -

[ESCAPE 1] 1 Z

where Z is the time zone digit and is between 1 and 5.

1.1.2.1.3 Real Time Entry

The real time is entered with the following key sequence -

[ESCAPE 1] 2 $H_1$ $H_2$. $M_1$ $M_2$. $S_1$ $S_2$.

where $H_1$, $H_2$ are the hours digits

$M_1$, $M_2$ are the minutes digits

$S_1$, $S_2$ are the seconds digits

1.1.2.1.4 Locomotive Number Entry

The locomotive number is entered with the following key sequence

[ESCAPE 1] 3 $L_1$ $L_2$ $L_3$ $L_4$.

where $L_1$ $L_2$ $L_3$ $L_4$ is the four digit locomotive number.

1.1.2.1.5 Station/Subdivision Entry

The station or subdivision number can be entered with the following key sequence:

[ESCAPE 1] 4 $S_1$ $S_2$ $S_3$ $S_4$.

where $S_1$ $S_2$ $S_3$ $S_4$ is the station or subdivision number.

1.1.2.1.6 Location Entry

The train location is entered with the following key sequence -

[ESCAPE 1] 5 $M_1$ $M_2$ $M_3$ $M_4$ $M_5$ .

where $M_1$ $M_2$ $M_3$ represent units miles

$M_4$ $M_5$ represent hundredths of miles

Note that there is no period delimiter between $M_3$ and $M_4$.

1.1.2.1.7 Wheel Diameter Entry

The wheel diameter for the engine is entered with the following key sequence -

[ESCAPE 1] 6 $W_1$ $W_2$ $W_3$ $W_4$.

where $W_1$ $W_2$ is the unit inch diameter of the wheels

$W_3$ $W_4$ is the diameter to a hundredth of an inch.

Note that the recorder is not designed to handle wheel diameters of less than about twenty-two inches. No delimiter is needed between $W_2$ and $W_3$.

1.1.2.1.8 Railroad Entry

The railroad number is entered with the following key sequence -

[ESCAPE 1] 7 R.

where R is the railroad number and is to be a value from Ø to 9.

1.1.2.1.9 Train Number Entry

The train number is entered with the following key sequence -

[ESCAPE 1] 8 $T_1$ $T_2$ $T_3$.

where $T_1$ $T_2$ $T_3$ is the three digit train number.

1.1.2.1.10 Operator's Name Entry

The operator's name can be entered with the following key sequence -

[ESCAPE 1] 9 $N_1$ $N_2$ $N_3$.

where $N_1$ $N_2$ $N_3$ is a three digit operator identification number.

1.1.2.2 Escape 2 Commands - Operation Control

1.1.2.2.1 Stop Recording

This command is entered with the following key sequence -

[ESCAPE 2] Ø

This command causes the recorder to stop recording changing data into the solid state memory. It will continue in this state until a start recording command is given. This mode is useful to ensure no further recording takes place while a memory dump is in progress.

1.1.2.2.2 Start Recording

This command is entered with the following key sequence -

[ESCAPE 2] 1

This puts the recorder into the record mode. This sequence is normally used after power on and all pertinent data has been entered into the computer (i.e. the escape 1 sequences).

This sequence can also be used to restart the recorder if it has been stopped for any reason (such as a memory dump).

1.1.2.2.3 Select Playback Mode

The playback mode can be activated by the following key sequence -

[ESCAPE 2] 2

This puts the recorder into the playback mode. In this mode, different commands can be used to play back the recorded data. The data can be displayed on a CRT display or a printer. The playback software is intended to be a subset of the software used in the stand alone playback system.

1.1.2.2.4 Cancel Command and Entry

The cancel command is entered with the following key sequence -

[ESCAPE 2] 3

This command will terminate any command line in progress, clear any display and be ready for another command line input.

1.1.2.2.5 Clear Keyboard Entry

The clear keyboard entry command is entered with the following key sequence -

[ESCAPE 2] 4

This command will cancel the last keyboard entry, but will enable the operator to continue entering the current input command line.

1.1.2.2.6 Display Date

The date can be displayed on an external terminal with the following key sequence -

[ESCAPE 2] 5

This command makes the recorder send the current date to the port that requested the date. The response will include the characters:

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF DATE $Y_1$ $Y_2$/$M_1$ $M_2$/$D_1$ $D_2$ ETX EOT

where SOH is a 'start of header' ASCII control character

$L_1$ $L_2$ $L_3$ $L_4$ is the locomotive number

STX is a 'start of text' ASCII control character

CR is an ASCII control code carriage return

LF is an ASCII control code line feed

$Y_1$ $Y_2$ is the years digits

$M_1$ $M_2$ is the months digits

$D_1$ $D_2$ is the days digits

ETX is an ASCII control code 'end of text'

EOT is an ASCII control code end of transmission

1.1.2.2.7 Display Real Time

Real Time can be displayed on an external terminal with the following key sequence -

[ESCAPE 2] 6

This command makes the recorder send the real time to the port that requested the date. The response will include the characters:

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF TIME $H_1$ $H_2$:$M_1$ $M_2$:$S_1$ $S_2$ ETX EOT

where $H_1$ $H_2$ is the current hours digits

$M_1$ $M_2$ is the minutes digits

$S_1$ $S_2$ is the seconds digits.

1.1.2.2.8 Display Locomotive Number

The locomotive number can be displayed with the following key sequence -

[ESCAPE 2] 7

This command makes the recorder send the locomotive number to the port that made the request. The response includes the characters:

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF LOCO # $L_1$ $L_2$ $L_3$ $L_4$ ETX EOT

where $L_1$ $L_2$ $L_3$ $L_4$ is the locomotive number.

1.1.2.2.9 Display Wheel Diameter

The wheel diameter can be displayed with the following key sequence -

[ESCAPE 2] 8

This command enables the recorder to send the wheel diameter to the port that made the request. The response includes the characters:

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF WHEEL DIA $W_1$ $W_2$.$W_3$ $W_4$ ETX EOT

where $W_1$ $W_2$ is the units inches diameter

$W_3$ $W_4$ is the hundredths of inches

1.1.2.2.10 Display Location

The location can be displayed with the following key sequence -

[ESCAPE 2] 9

This command enables the recorder to send the last entered mileage location to the port that made the request. The response includes the characters:

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF SUBDIVISION $S_1$ $S_2$ $S_3$ $S_4$ ETX EOT

where $S_1$ $S_2$ $S_3$ $S_4$ is the last entered subdivision

1.1.2.3 Escape 3 Commands

1.1.2.3.1 Display Memory Size

The memory size can be displayed with the following key sequence -

[ESCAPE 3] Ø

This command enables the recorder to send the solid state memory size to the port that made the request. The response will include the following message:

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF MEM SIZE Ø $N_1$ $N_2$ $N_3$ K ETX LP EOT

where $N_1$ $N_2$ $N_3$ is the number of kilobytes in this memory
(i.e. 128K is one hundred twenty eight kilobytes).

1.1.2.3.2 Display Elapsed Time

The elapsed time is displayed with the following key sequence -

[ESCAPE 3] 1

This command enables the recorder to send back the elapsed time from the time the recorder was last started. The response will include the following characters:

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF EL TIME $D_1$ $D_2$ $H_1$ $H_2$:$M_1$ $M_2$:$S_1$ $S_2$ ETX EOT

where $D_1$ $D_2$ is the number of elapsed days since the last entered time

$H_1$ $H_2$ is the number of elapsed hours

$M_1$ $M_2$ is the number of elapsed minutes

$S_1$ $S_2$ is the number of elapsed seconds

1.1.2.3.3 Display Calculated Location

The calculated location is displayed with the following key sequence -

[ESCAPE 3] 2

This command enables the recorder to send the calculated distance to the port that made the request. The response includes the following message sequence:

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF LOCATION $M_1$ $M_2$ $M_3$.$M_4$ $M_5$ ETX EOT

where $M_1$ $M_2$ $M_3$ are the units miles

$M_4$ $M_5$ are the hundredths miles

1.1.2.3.4 Display Identification

Identification can be displayed by entering the following key sequence -

[ESCAPE 3] 1

This command enables the recorder to send the operator's name identification number to the port that made the request. The response will include the following message:

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF ZONE Z TRAIN $T_1$ $T_2$ $T_3$ $T_4$ ETX EOT

where Z is the time zone, $T_1$ $T_2$ $T_3$ $T_4$ is the train number

1.1.2.3.5 Display Speed

Speed can be displayed by entering the following key sequence -

[ESCAPE 3] 4

This command enables the recorder to send the speed to the port that made the request. The response includes the following message sequence -

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF SPEED $S_1$ $S_2$ MPH ETX EOT

where $S_1$ $S_2$ are the digits that represent the units speed in miles per hour

1.1.2.3.6 Display Throttle

The throttle position can be displayed by entering the following key sequence -

[ESCAPE 3] 5

This command enables the recorder to send the throttle position to the port that made the request. The response includes the following message sequence -

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF THROTTLE N ETX EOT

where N is the throttle position number from Ø to 9.

1.1.2.3.7 Display Dynamic Brake

The dynamic brake status can be displayed by entering the following key sequence -

[ESCAPE 3] 6

This command enables the recorder to send the dynamic brake status to the port that made the request. The response includes the following message sequence -

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF DYNAMIC BR D ETX EOT

where D is the dynamic brake status and is Ø for off and 1 for on.

1.1.2.3.8 Display Brake Pipe Pressure

The brake pipe pressure can be displayed by entering the following key sequence -

[ESCAPE 3] 7

This command enables the recorder to send the brake pipe pressure to the port that made the request. The response includes the following message sequence -

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF BRAKE PIPE $P_1$ $P_2$PSI ETX EOT

where $P_1$ $P_2$ is the brake pipe pressure in pounds per square inch.

1.1.2.3.9 Display Independent Brake Cylinder Pressure

The independent brake cylinder pressure can be displayed by entering the following key sequence -

[ESCAPE 3] 8

This command enables the recorder to send the independent brake cylinder pressure to the port that made the request. The response includes the following message sequence -

SOH CR LF $L_1$ $L_2$ $L_3$ $L_4$ STX CR LF INDPNDNT BR $I_1$ $I_2$ PSI ETX EOT

where $I_1$ $I_2$ is the independent brake cylinder pressure in pounds per square inch.

1.1.2.3.10 Display Status

The recorder status can be displayed by entering the following key sequence -

[ ESCAPE 3 ] 9

This command instructs the recorder to send the recorder status to the port that made the request. The response includes all the messages contained in sections 1.1.2.3.3 to 1.1.2.3.9 inclusive.

1.1.2.4 Escape 4 Commands

1.1.2.4.1 Recorder Reset

The recorder can be put into the reset state identical to a power on sequence by entering the following key sequence -

[ ESCAPE 4 ] Ø 9 1 3 8.

This command will clear the recorder memory and set the mode to record initialize. All fixed parameters such as locomotive number will be reset, and will have to be entered to set the recorder up. This command would probably be used after a recorder dump, to ensure that all the old data is cleared out. This would ensure that old data is not retained after a memory dump.

1.1.2.4.2 Memory Dump

The recorder can be used to get a memory dump from a second recorder. It is

done by issuing the following key sequence -

[ESCAPE 4] 1 P .

where P is either 1 or 2, corresponding to the port desired to be used for the memory dump.

This command was put into the recorder so that a portable memory unit could use the same program as the recorder software. This command, then, is really only intended for use in portable memory units so that memory dumps can be done without creating special software for the portable memory.

1.1.2.4.3 Set Port Baud Rate

The baud rate and configuration of each port can be specified with this impact command -

[ESCAPE 4] 2 P N.

where P is the desired port (either port 1 or port 2)

N is the desired baud rate and port configuration and has a value of Ø to 9. A table for port speed and configuration is given below for each value of N:

| N | DESCRIPTION |
|---|---|
| Ø | 11Ø baud, 7 bits/char, even parity, 2 stop bits |
| 1 | 150 baud, 7 bits/char, even parity, 2 stop bits |
| 2 | 300 baud, 7 bits/char, even parity, 2 stop bits |
| 3 | 600 baud, 7 bits/char, even parity, 2 stop bits |
| 4 | 1200 baud, 7 bits/char, even parity, 2 stop bits |
| 5 | 1200 baud, 8 bits/char, even parity, 1 stop bit |
| 6 | 2400 baud, 8 bits/char, even parity, 1 stop bit |
| 7 | 9600 baud, 8 bits/char, even parity, 1 stop bit |
| 8 | 19200 baud, 8 bits/char, even parity, 1 stop bit |
| 9 | 38400 baud, 8 bits/char, even parity, 1 stop bit |

1.1.2.4 4 Enter Traction Motor Current Averaging Interval

This routine enters a traction motor current averaging time interval. It defaults to five seconds at power on, and can be set to a maximum of a nine second interval. This time interval is specified with the following keyboard sequence:

ESCAPE 4 3 N.

where N is the desired time interval with valid entries from 1 to 9.

1.1.2.4.5 Enter Non-Volatile Ram Recording Interval

The non-volatile ram is initially set to record on one second intervals. This rate can be reduced by entering the following sequence:

ESCAPE 4 4 N.

where N is the desired time interval, with valid entries from 1 to 9. Note that the data is always recorded each time interval in the non-volatile memory, regardless of whether any changes have actually taken place or not.

1.1.2.4.6 Enter Non-Volatile Ram Size

The size of the non-volatile memory can be entered with the following sequence:

ESCAPE 4 5 $N_1 N_2 N_3 N_4$.

where $N_1 N_2 N_3 N_4$ is a four digit, decimal value of the number bytes of non-volatile memory. Note that at power on, this value is set to 4096 (4 K bytes). This default value could be made less by entering the appropriate numbers (i.e. - $N_1 N_2 N_3 N_4$ = 1024 for 1 K byte memory size). This command is useful where the amount of non-volatile memory is less than 4 K bytes. Currently, there is a maximum of 4096 bytes, and so numbers larger than this should not be entered.

1.1.2.5 Escape 5 Commands

1.1.2.5.1 Enter Offset

The analog offset voltages can be taken into account by subtracting the digital value corresponding to a value representing zero volts input. This is done with the following key sequence -

[ESCAPE 5 ] Ø

Before this command is issued, all sensors should be set for a zero reading (i.e. bleed the brake pipe until the pressure is zero - the resulting analog voltage and its digital equivalent represents a zero pressure value. This fixed digital value is then subtracted from all subsequent readings of brake pipe to yield true readings).

1.1.2.5.2 Clear Offset

The analog offsets determined from section 1.1.2.5.1 can be cleared by entering the following key sequence -

[ESCAPE 5 ] 1

This command will clear any offsets set up in the procedure described in section 1.1.2.5.1.

1.1.3 Data Transmission Control

1.1.3.1 Transmit the First Record Block

The recorder unit will transmit the first block of recorded data to a remote computer in response to a "DUMP" command from the remote computer.

" DUMP" command sequence -

ENQ

1.1.3.2 Transmit the Next Recorded Block

The recorder unit will transmit the next block of recorded data to a remote computer in response to an "ACK" code sequence from the remote computer.

ACK code sequence -

ACK

1.1.3.3 Transmit the Previous Record Block

The recorder unit will transmit the last block of recorded data to a remote computer in response to an "NAK" code sequence from the remote computer.

NAK code sequence -

NAK

1.1.3.4 Recorder Responses to Transmit Control Commands

In response to a transmit control command (ENQ, ACK, NAK) the recorder transmits the block of recorded data in transparent ASCII mode.

1.1.4 Special Considerations

The above key code sequences are transmitted to the recorder as coded ASCII messages and thereby could be automatically generated by a remote source such as:

- Host dispatcher's computer
- Signal mast transponder

The recorder will transmit (for printout) specified sections of the recording in response to the respective printout command sequences used for the playback system.

## 1.2 Installation

The recorder unit is provided with a simple slide on-latching wall mounting assembly.

Signals and power are brought into the recorder by connecting the two 23 pin connectors that are part of the mounting base.

The DC power should be within the following limits -

Minimum - 60 VDC

Maximum - 80 VDC

## SECTION 2 - PORTABLE MEMORY UNIT

### 2.0 GENERAL DESCRIPTION

The Portable Memory Unit is designed only for the short periods of operation required for extracting data from the Recorder and loading data into the Playback System.

The Portable Memory Unit has four operating modes as follows:

Mode 1 - Transmit Data Mode

(AC Power) In this mode the unit is loading recorded data into the Playback System

Mode 2 - Guarded Memory Mode

(No AC Power) In this mode the unit is idling on battery power and will not receive or transmit data.

Mode 3 - Receive 1st Recording Mode

In this mode the unit receives a recording from the RECORDER unit and stores it at the start of its memory.

Mode 4 - Receive Next Recording Mode

(Future Enhancement) In this mode the unit receives a recording from the RECORDER unit and stores it in the next available memory space.

Note - The portable memory should always be set to mode 1 except when the operator is extracting a recording from the Recorder Unit.

### 2.1 Operating Procedures

2.1.1 Load Portable Memory From Recorder

2.1.1.1 Carry the portable unit to the locomotive. Connect a dump cable between port 1 of the recorder and port 1 of the portable memory. Connect a portable keyboard to the portable memory, port 2, if one is available (the keyboard is not mandatory).

2.1.1.2 Turn on the 5V power switch to power the portable memory. Also turn on the battery power switch.

2.1.1.3 Turning on the portable memory power with the dump cable connected initiates a dump from the recorder to the portable memory. After each 16K block of data has been loaded into the portable memory, the portable memory will send the last block number to the keyboard, where it can be displayed. With 128K bytes of recorder memory, there are a total of eight blocks, from Ø1 to Ø8. After the value Ø8 has been displayed on the keyboard, the loading will be complete. If the recorder had 512K bytes of memory, then the last block number will be 32. As well, the LED's on the switch panel will show a binary number equivalent to that sent to the portable keyboard. When the transfer is complete, all the eight data LED's will turn on.

2.1.1.4 When the dump is complete, remove the dump cable and switch off the 5V power switch. Leave the battery power switch on.

2.1 1.5 For portable memory units with 512K bytes of solid state memory, multiple dumps may be done if the software allows, under the following conditions:

i) Each recorder has less than 512K bytes of memory.

ii) Restrict battery usage to not more than half an hour before returning the unit to 110 volt power to guarantee the integrity of the data in the portable memory unit.

As an example, up to four recorders could be handled with one portable memory unit if each recorder had 128K bytes of memory. The first memory dump is done as described in sections 2.1.1.1 to 2.1.1.4. After the first dump is complete, the power to the recorder should be switched off (5V power switch). This will maintain battery backup, but will not keep the rest of the electronics running. This will help extend the battery

life as the portable unit is carried to other locomotives. After connecting the portable unit to the next recorder to have its memory dumped, switch the portable unit back on (5V power on) and depress the reset button. Follow the procedure described in sections 2.1.1.2 to 2.1.1.5.

2 1.2 Transfer Data to the Playback Unit

This section describes the procedure involved in transferring the data from the portable memory unit to the playback unit. 110 volt A.C. power should be restored to the portable memory as soon as it is returned to the location where the data transfer to the playback unit will take place.

2.1.2.1 Connect port 1 of the portable unit to port 1 of the playback system (Note: Ensure power to the portable memory is on before connecting this.)

2.1 2.2 Initiate the dump from the playback system with the following keyboard command:

ESC L 1 [CR]

This will start the dump operation. When the data transfer is complete, a message "M512 LOADED' will appear on the status line of the playback unit.

2.1.2.3 After the data transfer is complete, the cable between the playback unit and the portable memory can be removed The data in the playback unit can then be stored on disk and played back. See section 3.1 for complete operational features of the playback unit.

2.1.2.4 The portable memory should be left on to allow the batteries to recharge. It is highly recommended that the unit be removed from its environmental shroud during this time. Twelve to sixteen hours should be sufficient to fully recharge the batteries.

Ensure that the main power switch and battery power switch are left on, and set the 5V power switch off. If the portable unit is to be left unused for more than a day, the power should be sut off the day after the data transfer has taken place. Ensure that the battery power switch is turned off to ensure that the batteries do not discharge while keeping the memory enabled.

## 2.2 Fault Diagnostic Testing

The portable memory unit uses the same diagnostic test procedures as described in Section 4. Note that the portable memory unit only has three boards to check:

90 GPP Ø 1

88 M512 Ø 1

90 TCA Ø 1

# SECTION 3 - PLAYBACK SYSTEM

## 3.0 GENERAL DESCRIPTION

The Playback System is a basic VISTA 90 microprocessing system with custom software features.

The system comprises the following main components -

a) VISTA 90 Microprocessor Controller

b) VISTA 90 Keyboard Unit

c) VISTA 90 Dual Diskette Drive

d) Printer Unit

e) CRT Display Unit

f) VISTA 90 Operating System

## 3.1 Operating Procedures

3.1.1 The hardware is connected together as described in 3.2.

3.1.2 Turn on

The operating system is turned on as follows:

a) Set all mode switches low

b) Switch on the AC power

c) Insert the operating system diskette into Drive Ø

d) Depress the reset button

The cursor will appear on the CRT when the system is ready for use.

3.1.3 Load Recording From RS232C Port

The playback system loads the recording into its memory from the specified RS232C port in response to a "Load Port" Command from the keyboard operator. The port specified can be either port 1 or port 2. The key input sequence is:

ESC L [1/2] CR

where [1/2] specifies either port 1 or 2 but not both

i.e. ESC L 1 CR requests that the loading be done through serial port 1.

3.1.4 Transfer Memory to Disk

The playback system transfers the contents of the recording memory to diskette in response to the following key sequences -

Transfer to Drive Ø [ESC] 0 Ø [CR]

Transfer to Drive 1 [ESC] 0 1 [CR]

3.1.5 Transfer Disk to Memory

The playback system transfers the contents of the diskette to the recording memory in response to the following key sequences -

Transfer from Drive Ø [ESC] [ Ø [CR]

Transfer from Drive 1 [ESC] [ 1 [CR]

3.1.6 Parameter Abbreviations

In order to analyze the recorded data conditionally or upon exception only, it is necessary to specify the requested parameter(s) with a two letter code. The following list specifies all of the two letter codes as well as a description of their representation. Except for any future expansion, all other code combinations will result in a keyboard entry error with no action being taken on this undefined code combination.

| | |
|---|---|
| TI | time |
| ZN | zone |
| TR | train number |
| LO | locomotive number |
| TK | track number |
| ST | station number |
| MI | Mileage value (no fractions) |
| VL | velocity (miles per hour) |
| TH | throttle |
| AM | traction motor current |
| DB | dynamic brake |
| BP | brake pipe pressure |
| IB | independent brake pressure |
| EB | equalizing reservoir pressure |
| LE | locomotive initiated emergency |
| LP | lead unit power |
| SA | sanding |
| WH | whistle |
| MD | engine direction |
| WC | wheel creep |
| PC | pneumatic cut-out |
| AB | auto brake |
| LC | loss of continuity |
| SP | system power |
| MU | MU mode |
| ID | independent mode |
| CL | 1Ø KHz clock |
| PB | penalty brake |
| NW | last recorded chunk only |

3.1.7 Select Start Condition for Display (printout)

The playback system selects the start condition for display or printout in response to the following key sequence.

Example 1 - Reset any previously specified start condition

[ESC] B [CR]

Example 2 - Set Printout Start Condition to Newest Segment of Recording

[ESC] BNW [CR]

Example 3 - Set Printout Start Condition to Break Pipe Pressure

60 PSI

[ESC] BBP > 6Ø [CR]

Example 4 - Set Printout Start Condition Sanding On

[ESC] BSA = 1 [CR]

Example 5 - Set Printout Start Condition to Time March 12, 10:05 o'clock

[ESC] BTI = 03, 12, 10, 05 [CR]

3.1.8 Select End Condition for Display (Printout)

The playback system selects the END condition for display or printout in response to the following key sequence:

Same as 3.1.7 except as follows:

Example - Set Printout End Condition to Break Pipe Pressure

Less than 50 PSI

[ESC] EBP < 5Ø [CR]

3.1.9 Exceptions

Instead of displaying all parameters between start and end conditions, it is possible to display only exceptional data. This can be done with the following key sequence:

[ESC] X NN = PARAMETER [CR]

where NN is a particular recorded event -

i.e. [ESC] X VL > 55 [CR]

will cause only those lines of data to be displayed (and printed if requested) in which the velocity was greater than 55 miles per hour.

3.1.10 Display Selected Data

The playback system can be made to display the data by typing the following key .

[PRINT]

This will display all the data stored in the recorder. This key produces a special character not available on many keyboards. The software has been written to accept a second character to accomplish the same function. The alternate key is:

[CNTRL] Z

This control code can be generated from many standard keyboards, including the portable keyboard. If a begin condition, end condition or exception condition has been previously specified, then the display will be limited to the data that is defined by these limits.

The status line will show 'DISPLAY ONLY' to show that a display data process is in operation.

3.1.11 Print Selected Data

Data can be output to a printer with the following two key sequence:

[XMIT] [$\frac{1}{2}$]

After the XMIT key has been depressed, a message will appear on the status line of the display as follows:

'PRINT TO PORT'

The system is ready to accept the number 1 or 2 to determine the output port to be used. For systems using standard keyboards without the specially encoded XMIT key, the same effect can be achieved by using the following key:

[CNTRL] Y

If any condition such as start, end or exception has been specified, then the printout will be restricted to the data that meets the specified condition(s).

3.1.12 Erase Page

The playback system erases the CRT recording display area by depressing the ERASE key. It can also be done with a [CNTRL] > .

3.1.13 Cancel Command

The playback system cancels the present command or operation by depressing the CLR key. This is a specially encoded key on the playback keyboard. If a standard keyboard is used, then the software will also recognize [ CNTRL ] X as a cancel command key. This is especially useful on keyboards such as the portable keyboard.

3.1.14 Increment Line

The display can be displayed one line at a time while the playback unit is in the pause mode To start the display, put the playback system into the pause mode (see section 3.1.20). Start the display by entering display (section 3.1.10) or print (section 3.1.11). The first line of appropriate data will be displayed on the screen. Further lines can be displayed by depressing the + key. To resume normal mode, enter the continue command (section 3.1.21). This key can be substituted for a [ CNTRL ] K key on a standard keyboard.

3.1.15 Increment Page

The display can be displayed one page at a time by entering the [ TAB ] key. A [ CNTRL ] = key will achieve the same result. The playback must be in the pause mode initially, and the display has to be started with the display key (see section 3.1.10) or print (section 3.1.11). To resume normal display, enter the 'continue' command (section 3.1.21).

3.1.16 Copy Disk Drive Ø to Disk Drive 1

The playback system copies drive Ø diskette to drive 1 diskette in response to the following key sequence -

[ ESC ] Z CR

3.1.17 Select Printer CR/LF Delays

A delay after each CR/LF sequence can be introduced to mechanically allow time for a printer to physically return the print head to the left hand side and do a line feed. This delay is done by inserting a programmable number of null codes after a CR/LF code sequence. It is invoked with the following key sequence:

[ ESC ] N [ $\frac{1}{2}$ ] X [ CR ] where [ $\frac{1}{2}$ ] is port 1 or port 2 and X is a number from Ø to 9, and is the number of null codes to be filled into the text after each CR/LF code sequence. At power on, this value is set to zero.

3.1.18 Return to Recorder Display

The recorder can be returned to by issuing an [ ESC2 ] key or a [ CNTL ] S key. Note that unless the recorder was stopped ( [ ESC2 ] Ø sequence) before the playback mode was entered, the recorder will continue to function normally. Thus, subsequent display or print requests may show further data as changing parameters are added to the recorder memory

3 1.19 Select Printer Speed

The playback system selects the serial port speeds in response to the message sequences as follows:

[ ESC ] S [ $\frac{1}{2}$ ] N [CR ]

where [ $\frac{1}{2}$ ] selects either port 1or port 2.

N is a value from Ø to 9 and is used for speed selects as follows:

| N | DESCRIPTION |
|---|---|
| 0 | 110 baud, 7 bits/char, even parity, 2 stop bits |
| 1 | 150 baud, 7 bits/char, even parity, 2 stop bits |
| 2 | 300 baud, 7 bits/char, even parity, 2 stop bits |
| 3 | 600 baud, 7 bits/char, even parity, 2 stop bits |
| 4 | 1200 baud, 7 bits/char, even parity, 2 stop bits |
| 5 | 1200 baud, 8 bits/char, even parity, 1 stop bit |
| 6 | 2400 baud, 8 bits/char, even parity, 1 stop bit |
| 7 | 9600 baud, 8 bits/char, even parity, 1 stop bit |
| 8 | 19200 baud, 8 bits/char, even parity, 1 stop bit |
| 9 | 38400 baud, 8 bits/char, even parity, 1 stop bit |

Note that at power on, port 1 is internally initialized for 19200 baud, 8 bits/character, even parity and 1 stop bit, while port 2 is set for 1200 baud, 7 bits per character, even parity and two stop bits

3.1.20 Pause

The pause command can be used to stop any display or print command currently in progress It is given by the following key: [ ERASE EOL ] . On a standard keyboard it can also be done with the [ CNTRL ] < key.

3.1.21 Continue

If the playback system is in the pause mode, it can be returned to the normal mode by depressing the [ TAB SET ] key on a standard keyboard, or the [ CNTRL ] N key. If any display or print were suspended, then this last command would continue to completion before more keyboard commands would be executed.

3.1.22 Escape Sequences

All escape sequences are started with the escape key [ ESC ] and are terminated by the [ enter ] key, or the [ CR ] key.

3.1.23 Escape Mode Editing

While entering ascape sequences, mistakes can be modified with certain editing functions as follows:

[ CHR INS ] or [ CNTRL ] V - insert a character position space at the cursor position. The cursor position does not move.

[ CHR DEL ] or [ CNTRL ] G - delete the character at the cursor position. All characters to the right of the cursor move one position to the left.

[ → ] or [ CNTRL ] I - move the cursor one position to the right

[ ← ] or [ CNTRL ] H - move the cursor one position to the left

3.1.24 Setting Lines per Printer Page

The number of lines per printer page can be set with the following command:

[ ESC ] P [ 1/2 ] $N_1N_2$ [ CR ]

where: [ 1/2 ] represents the port to which the printer is connected

$N_1N_2$ is the total number of lines per page. $N_1N_2$ must be in the range from Ø to 99.

Initially, both ports are initialized for 66 lines per page. This is the correct count for 11 inch fan fold paper, printing six lines per inch. If different paper heights are used, or a different number of lines per inch is used, then this number should be adjusted accordingly.

## TRANSLATION TABLE FOR KEYSTROKES IN USERS MANUAL

| KEYSTROKE | ASCII CODE (IN HEXADECIMAL) | PORTABLE KEYBOARD | HONEYWELL KEYBOARD | V90 KEYBOARD |
|---|---|---|---|---|
| [ESCAPE 1] | 11 | [CNTRL] [Q] | [CNTRL] [Q] | [CNTRL] [Q] |
| [ESCAPE 2] | 12 | [CNTRL] [R] | [CNTRL] [R] | [CNTRL] [R] |
| [ESCAPE 3] | 13 | [CNTRL] [S] | [CNTRL] [S] | [CNTRL] [S] |
| [ESCAPE 4] | 14 | [CNTRL] [T] | [CNTRL] [T] | [CNTRL] [T] |
| [ESCAPE 5] | ØF | [CNTRL] [O] | [CNTRL] [O] | [CNTRL] [O] |
| [ESC] | 1B | [ESC] | [ESC] | [▶] |
| [PRINT] | 1A or EE | [CNTRL] [Z] | [PRINT] | [CNTRL] [Z] |
| [XMIT] | ED or 19 | [CNTRL] [Y] | [XMIT] | [CNTRL] [Y] |
| [ERASE] | 8A or 1E | [CNTRL] | [ERASE] | ↓ |
| [↑] | ØB or 81 | [↑] | [↑] | [CNTRL] [K] |
| [CLR] | E7 or ØC | [CNTRL] [X] | [CLR] | [CR] |
| [CR] | ØD | [CR] | [RETURN] | [CNTRL] [M] |
| [TAB] | 1D or 89 | [CNTRL] [=] | [TAB] | [◀] |
| [TAB SET] | E5 or ØE | [CNTRL] [N] | [TAB SET] | [CNTRL] [N] |
| [CHR INS] | 8Ø or 16 | [CNTRL] [V] | [CHR INS] | [CNTRL] [V] |
| [CHR DEL] | 9Ø or Ø7 | [CNTRL] [G] | [CHR DEL] | [CNTRL] [G] |
| [→] | 83 or Ø9 | [→] | [→] | [CNTRL] [I] |
| [←] | 84 or Ø8 | [←] | [←] | [CNTRL] [H] |

# APPENDIX 'C'

# TESTING

# SPECIFICATIONS FOR THE

# TRAIN DATA RECORDING SYSTEM

Transportation Development Centre

Transport Canada

Montreal, Quebec

April 1984

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## SECTION 1: GENERAL REQUIREMENTS

1.1 The Train Data Recording System (TDRS) consists of a recorder and memory unit enclosed in an environmental shroud. Being located in the forward locomotive of the train, it is subjected to a wide range of harsh environmental conditions as well as electromagnetic interference. In view of the fact that the TDRS must operate successfully in all conditions, it is imperative that it conform to the following specifications.

1.2 A failure of the TDRS unit consists of:

a) Any incorrect digital output.

b) Any incorrect analog output outside the range ± 2% of the correct value.

Note: A deformation or rusting of the unit shall not constitute a failure unless it causes a) or b) above.

1.3 All testing is to be performed with the unit enclosed in the environmental shroud mounted right way up using its normal mounts. Unless otherwise specified, measurements and tests shall be taken at room ambient temperature, atmospheric pressure and relative humidity.

1.4 Mention of the acceptance test refers to the "Acceptance Test Procedure for the Train Data Recording System".

## SECTION 2: HIGH TEMPERATURE TEST

2.1 Place TDRS in environmental chamber at ambient conditions.

2.2 Raise temperature of chamber to 40°C within 30 minutes.

2.3 Maintain at 40°C for 6 hours.

2.4 Raise chamber temperature to 70°C within 1 hour and maintain at 70°C for 4 additional hours.

2.5 Lower the chamber temperature to 40°C within 30 minutes.

2.6 Repeat parts 2.3, 2.4 and 2.5 two additional times, making a total of three 12 hour tests.

2.7 While at 40°C, perform the acceptance test and analyse results for possible failure. Perform Voltage Variation Test, Section 10.

.../2

SECTION 3: LOW TEMPERATURE TEST (Ref: MIL-STD-810C, method 502.1)

3.1 Place TDRS in environmental chamber at ambient conditions.

3.2 Lower temperature of chamber to -40°C within 2 hours.

3.3 Maintain chamber temperature at -40°C for 24 hours ensuring relative humidity is not in excess of 15%.

3.4 After the 24 hours and while still in the -40°C chamber, perform the acceptance tests after allowing 10 minutes for readings to stabilize. Analyse results for possible failure. Perform Voltage Variation Test, Section 10.

3.5 Return chamber temperature to ambient within 2 hours.

3.6 Perform the acceptance test under the now ambient conditions and analyse results for possible failure.

SECTION 4: TEMPERATURE SHOCK (Ref: MIL-STD-810C, method 503.1)

4.1 Place TDRS at a room temperature into an environmental chamber.

4.2 Raise temperature of chamber to 40°C within 30 minutes and maintain for 4 hours.

4.3 Within 5 minutes, transfer the TDRS into a cold temperature chamber precooled to -40°C.

4.4 Maintain in the cold temperature chamber for 4 hours.

4.5 Within 5 minutes, transfer the TDRS into the hot temperature chamber which has been maintained at 40°C and leave for 4 hours.

4.6 Repeat steps 4.3, 4.4 and 4.5.

4.7 Repeat steps 4.3 and 4.4.

4.8 Return TDRS to ambient conditions and let stabilize.

4.9 Perform the acceptance test and analyse results for possible failure.

SECTION 5: HUMIDITY (Ref: MIL-STD-810C, method 507.1)

5.1 Raise the temperature and relative humidity of an environmental chamber to 30°C and 94 ± 4% respectively.

5.2 Place TDRS in the chamber and subject it to two continuous 48 hour cycles according to figure 5-1. Acceptance testing is to be performed twice in each cycle where noted on the curve. Analyse test results for possible failure.

SECTION 6: VIBRATION (Ref: MIL-STD-810C, method 514.2)

6.1 Mount TDRS on to vibration test rig using normal mounting attachments.

6.2 Subject TDRS to vibration range of 2-100-2Hz as shown on curve W on figure 6-1 with a logarithmic time sweep of 12.5 minutes as shown in figure 6-2. The total cycling time is to be 2 hours.

6.3 Step 6.2 is to be performed three consecutive times - once along each of the 3 mutually perpendicular axis.

6.4 Upon conclusion, remove TDRS from mounts and perform acceptance test. Analyse results for any possible failures.

SECTION 7: SHOCK (Ref: MIL-STD-202F, method 213B, MIL-STD-810C, method 516.2)

7.1 Fasten TDRS to shock machine using normal mounts. Shock machine may be of the free fall, resilient rebound, non resilient, hydraulic, compressed gas or other activating types.

7.2 The shock machine shall first be calibrated using a rigid dummy mass with the same centre of gravity as the TDRS test item to conform to the following specified wave forms. Two consecutive shock applications to the calibration load shall produce wave forms which are all within the tolerance envelope given in figure 7-1 and 7-2.

7.3 The frequency response of the complete measuring system, including the transducer through the readout instrument, shall be as specified by figure 7-3.

7.4 The TDRS test item shall be subjected to three shocks in each direction along three mutually perpendicular axes (total of 18 shocks). The shocks pulse shape shall be in accordance with either figure 7-1 or figure 7-2 using the underlined procedure (I) with amplitude (20g) and time duration (.011 sec.). During the test, the TDRS is to be operating.

7.5 At the conclusion of the shock test, the acceptance test shall be performed and results analysed for possible failure.

SECTION 8: ELECTRO MAGNETIC INTERFERENCE (Ref: MIL-STD-461B Class A3 Post 4)

8.1 The TDRS must equal or exceed the requirements of the following tests:

MIL-STD-461B Test CE01
CS01
RE01
RS01
RS03

SECTION 9: ELECTRICAL SURGE (Ref: IEC 571 (1977))

9.1 Subject the TDRS to a surge of 1.5 Kv for 45u sec. with an impedance of 500Ω if circuit corresponds to Figure 9-1 or a surge of 1.8 Kv for 45u sec. with an impedance of 500Ω if circuit corresponds to Figure 9-2.

9.2 Perform acceptance test. Analyse results for possible failure.

SECTION 10: VOLTAGE VARIATION (Ref: ANSI C37.90-1971/IEEE STD. 313-1971)

10.1 Operate TDRS at 74 VDC and continue to operate while performing steps 10.2-10.4.

10.2 Increase voltage to 80 VDC. Analyse results of possible failures.

10.3 Decrease voltage to 30 VDC in 5 VDC steps from 74 VDC. Analyse results for possible failures at each step.

10.4 Operate at 74 VDC. Analyse results for possible failure.

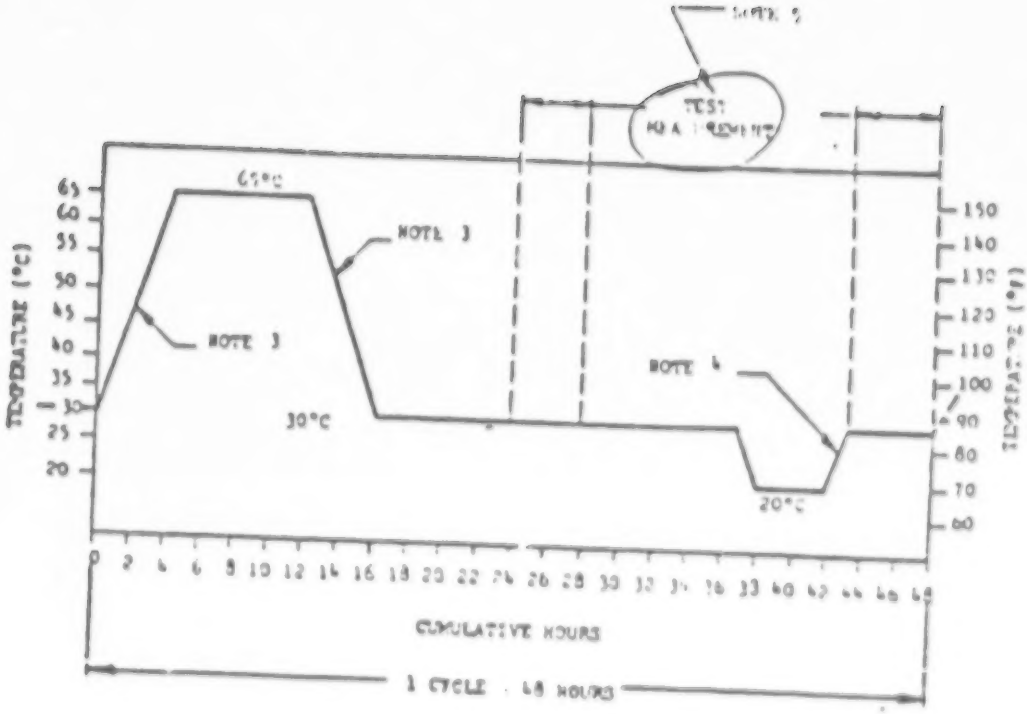



FIGURE 5-1 Humidity Cycle

NOTES:

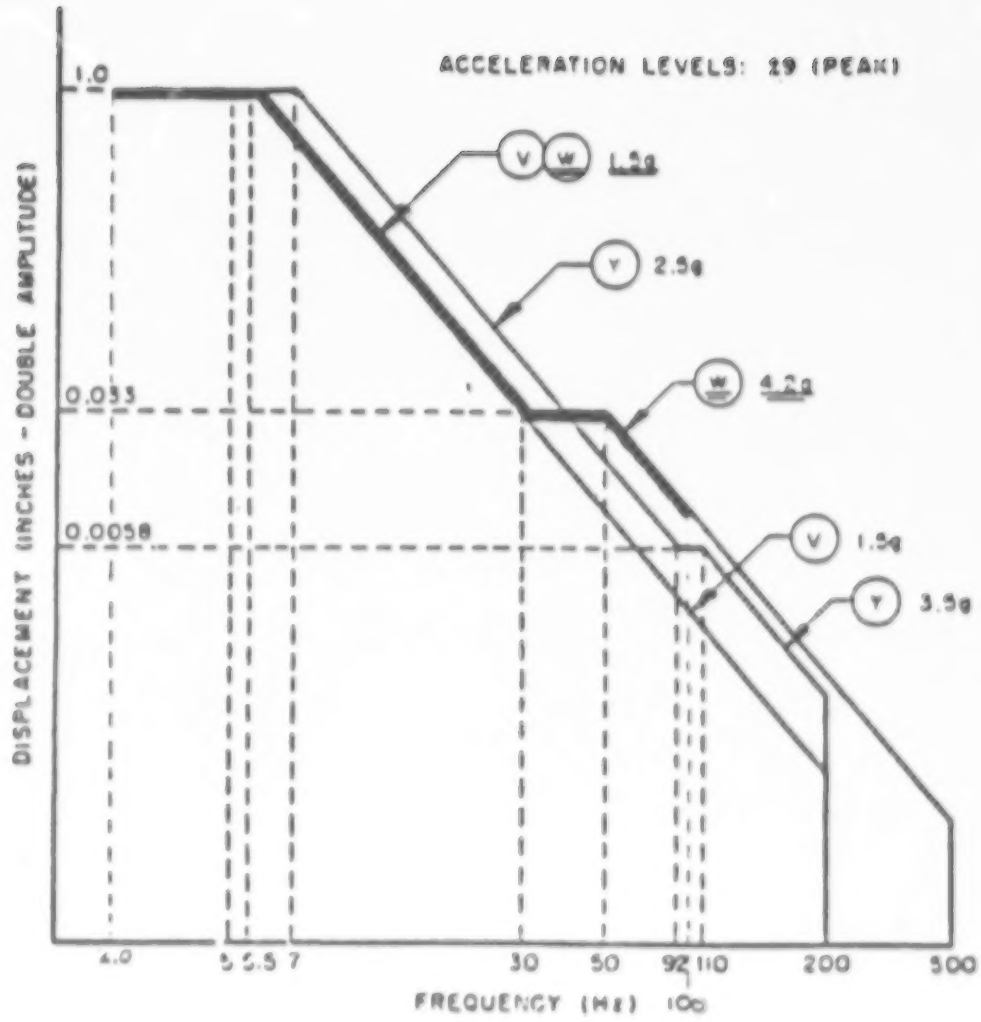
1. Tolerance during temperature change shall be not greater than 3°C (5°F).

2. Relative humidity shall be maintained at 94 ±4 percent at all times, except that during the descending temperature period, the relative humidity may be permitted to drop as low as 85 percent.

3. Rate of temperature change between 30° and 65°C (86° and 149°F) shall be not less than 8°C (14.4°F) per hour.

4. The temperature increase in this portion of the curve shall be not less than 10°C (18°F).

5. Test measurements shall be taken only at the period specified in the applicable equipment or system specification.




Note: All curves shall be extended to 2 Hz when test item resonances below 5 Hz are expected

Figure 6-1 Vibration Test Curves for Equipment Installed in Ground Vehicles

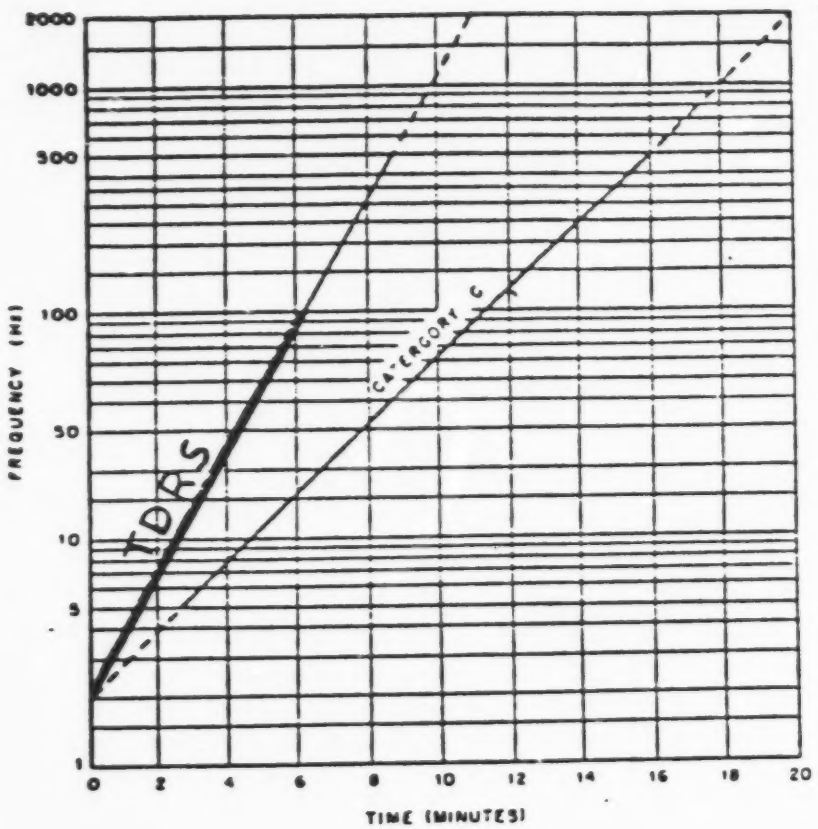
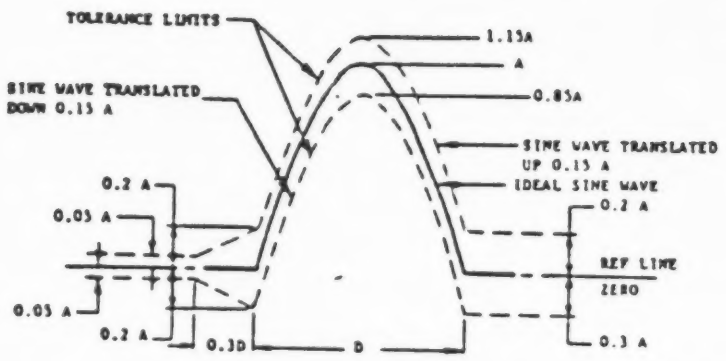



Fig 6-2 Logarithmic Sweep

MIL-STD-810C



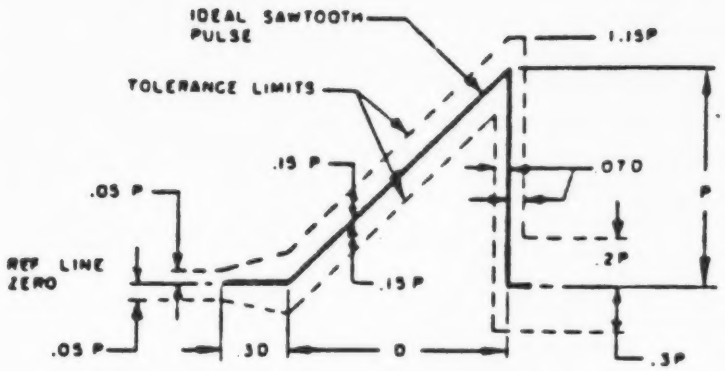

| PROCEDURE | TEST | PEAK VALUE (A) g's | | NOMINAL DURATION (D) ms | |
|---|---|---|---|---|---|
| | | FLIGHT VEHICLE EQUIPMENT a | GROUND EQUIPMENT b | FLIGHT VEHICLE EQUIPMENT c | GROUND EQUIPMENT d |
| I | BASIC DESIGN | 15 | 12 2/ | 11 | 11 |
| III | CRASH SAFETY | 30 | 60 | 11 | 6 |
| IV | HIGH INTENSITY | 100 | 100 | 6 | 6 |

1/ SHOCK PARAMETERS a AND c: RECOMMENDED FOR EQUIPMENT SHOCK MOUNTED OR WEIGHING 300 POUNDS OR MORE.

2/ EQUIPMENT MOUNTED ONLY IN TRUCKS AND SEMITRAILERS MAY USE A 20g PEAK VALUE.

NOTE: THE OSCILLOGRAM SHALL INCLUDE A TIME ABOUT 3D LONG WITH A PULSE LOCATED APPROXIMATELY IN THE CENTER. THE ACCELERATION AMPLITUDE OF THE IDEAL HALF SINE PULSE IS A AND ITS DURATION IS D. THE MEASURED ACCELERATION PULSE SHALL BE CONTAINED BETWEEN THE BROKEN LINE BOUNDARIES AND THE MEASURED VELOCITY CHANGE (WHICH MAY BE OBTAINED BY INTEGRATION OF THE ACCELERATION PULSE) SHALL BE WITHIN THE LIMITS $V_i \pm 0.1\ V_i$ WHERE $V_i$ IS THE VELOCITY-CHANGE ASSOCIATED WITH THE IDEAL PULSE WHICH EQUALS 2 AD/π. THE INTEGRATION TO DETERMINE VELOCITY CHANGE SHALL EXTEND FROM 0.4D BEFORE THE PULSE TO 0.1D AFTER THE PULSE.

FIGURE 7-1 Half Sine Shock Pulse Configuration and its Tolerance Limits



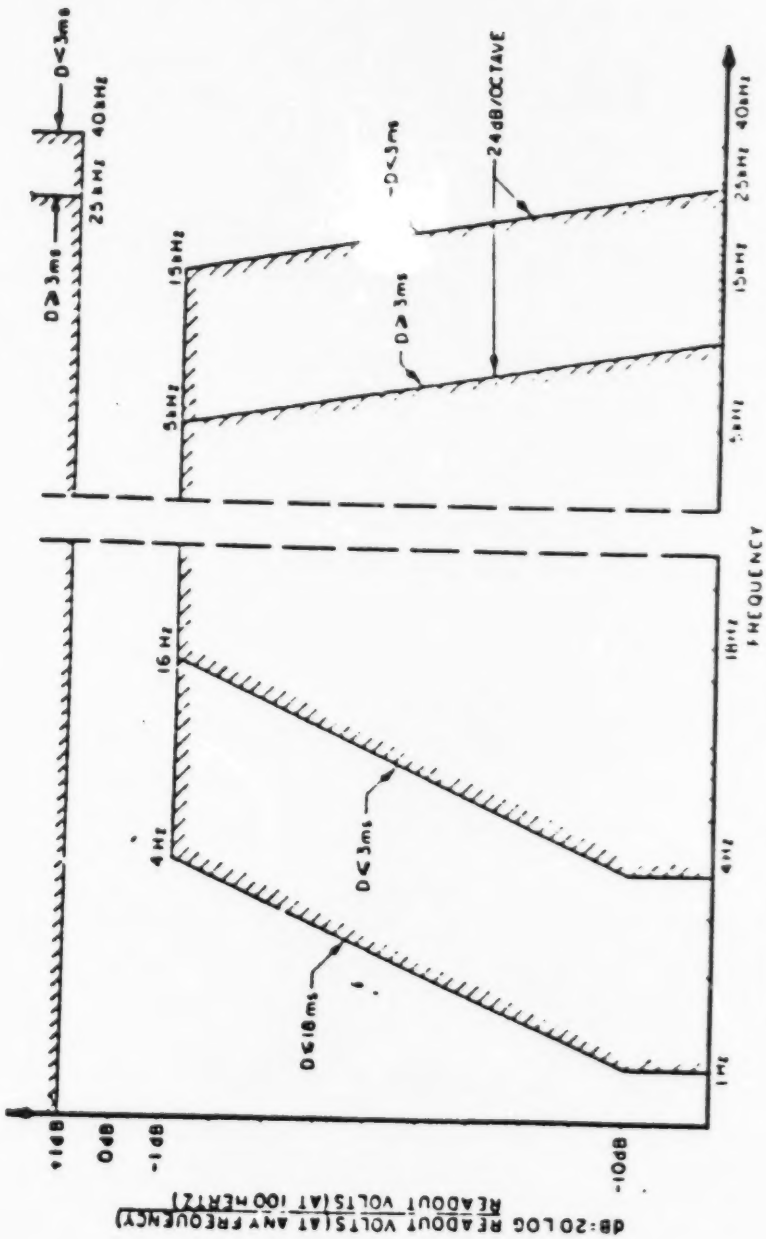

| PROCEDURE | TEST | PEAK VALUE (P) g's | | NOMINAL DURATION (D) ms | |
|---|---|---|---|---|---|
| | | FLIGHT VEHICLE EQUIPMENT a 1/ | GROUND EQUIPMENT b | FLIGHT VEHICLE EQUIPMENT c 1/ | GROUND EQUIPMENT d |
| I | BASIC DESIGN | 20 | 40 2/ | 11 | 11 |
| III | CRASH SAFETY | 40 | 75 | 11 | 6 |
| IV | HIGH INTENSITY | 100 | 100 | 6 | 11 |

1/ SHOCK PARAMETERS a AND c: RECOMMENDED FOR EQUIPMENT NOT SHOCK MOUNTED AND WEIGHING LESS THAN 300 POUNDS.

2/ EQUIPMENT MOUNTED ONLY IN TRUCKS AND SEMITRAILERS MAY USE A 20g PEAK VALUE.

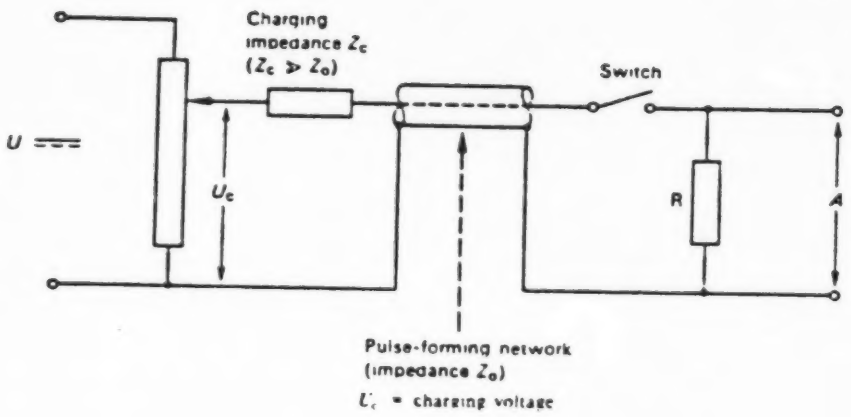
NOTE: THE OSCILLOGRAM SHALL INCLUDE A TIME ABOUT 3D LONG WITH A PULSE LOCATED APPROXIMATELY IN THE CENTER. THE PEAK ACCELERATION MAGNITUDE OF THE SAWTOOTH PULSE IS P AND ITS DURATION IS D. THE MEASURED ACCELERATION PULSE SHALL BE CONTAINED BETWEEN THE BROKEN LINE BOUNDARIES AND THE MEASURED VELOCITY CHANGE (WHICH MAY BE OBTAINED BY INTEGRATION OF THE ACCELERATION PULSE) SHALL BE WITHIN THE LIMITS OF $V_i \pm 0.1\ V_i$, WHERE $V_i$ IS THE VELOCITY-CHANGE ASSOCIATED WITH THE IDEAL PULSE WHICH EQUALS 0.5 DP. THE INTEGRATION TO DETERMINE VELOCITY CHANGE SHALL EXTEND FROM 0.4D BEFORE THE PULSE TO 0.1D AFTER THE PULSE.

FIGURE 7-2 Terminal-peak Sawtooth Shock Pulse Configuration and it. Tolerance Limits




| Duration of pulse (ms) | Low-frequency cut-off (Hz) -1dB | Low-frequency cut-off (Hz) -10dB | High-frequency cut-off (kHz) -1dB | Frequency beyond which the response may rise above +1dB (kHz) |
|---|---|---|---|---|
| 3 | 16 | 4 | 15 | 40 |
| <3 | 16 | 4 | 5 | 25 |
| 3 | 4 | 1 | 5 | 25 |
| >3 | | | | |

FIGURE 7-3 Tolerance limits for measuring system frequency response.


Charging
impedance $Z_c$
($Z_c \gg Z_o$)
Switch
U
$U_c$
R
A
Pulse-forming network
(impedance $Z_o$)
$U_c$ = charging voltage

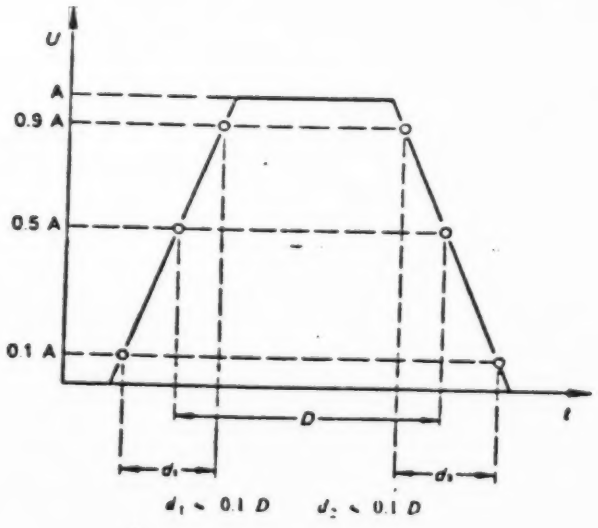
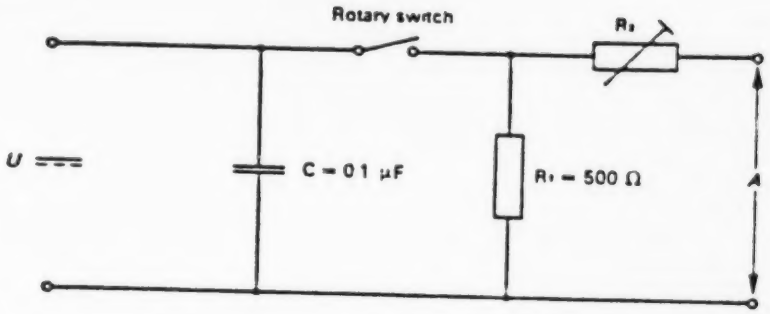

U
A
0.9 A
0.5 A
0.1 A
t
D
$d_1$
$d_2$
$d_1 \leq 0.1\ D$
$d_2 \leq 0.1\ D$

Figure 9-1


Rotary switch
R₂
U
C = 0.1 µF
R₁ = 500 Ω
A

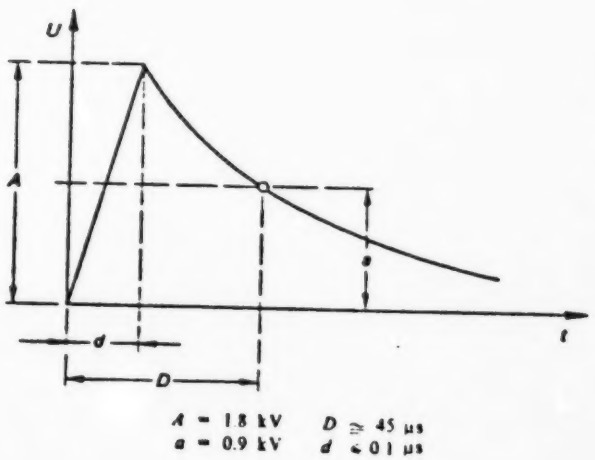

U
A
a
t
d
D
A = 1.8 kV
a = 0.9 kV
D ≅ 45 µs
d ≤ 0.1 µs

Figure 9-2

# APPENDIX 'D'

EXCERPTS FROM

DATA ACQUIRED BY RECORDER

ON CP LOCOMOTIVE NO.6022

November, 1983

The printout on the next page was generated by the playback system. The data was recorded during a period from November 1st, 1983 to November 3rd, 1983 and stored on a floppy diskette.

This printout shows the very first page of the recording. This excerpt is approximately 0.05% of all the data that was acquired on this run. The recorded data «wraps around» whenever the memory overflows. This allows the recorder to retain the latest data recorded and lose the oldest recording. This is why the recording starts at mileage 1,652.32. On a typical run the elapsed distance is approximately 1,000 miles.

DATE 01/11/83 ZONE 0 TRAIN 0456 LOCO 6022 TRAK 25 STN 2320 OP # 0000

| MILE | TIME | VL | T | AMPS | BP | IE | ER | F | R | T | P | W | B | S | C | L | V | Q | R | U | I | K | Y | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1652.32 | 01:07:18 | 39 | 5 | -0 | 77 | 03 | 76 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1652.33 | 01:07:19 | 40 | 2 | 0 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.34 | 01:07:20 | 39 | 2 | 0 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.36 | 01:07:22 | 39 | 2 | 273 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.37 | 01:07:23 | 39 | 2 | 273 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.38 | 01:07:24 | 39 | 2 | 273 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.41 | 01:07:27 | 39 | 0 | 148 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | | | | | | | | |
| 1652.42 | 01:07:28 | 39 | 0 | 148 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | | | | | | | | | | |
| 1652.43 | 01:07:29 | 40 | 0 | 148 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | | | | | | | | |
| 1652.45 | 01:07:30 | 39 | 0 | 148 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | | | | | | | | |
| 1652.46 | 01:07:31 | 39 | 0 | 148 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.47 | 01:07:32 | 40 | 0 | 54 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.48 | 01:07:33 | 39 | 0 | 54 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.49 | 01:07:34 | 39 | 0 | 54 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.52 | 01:07:37 | 39 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.54 | 01:07:39 | 39 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.56 | 01:07:41 | 40 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.57 | 01:07:42 | 39 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.59 | 01:07:43 | 40 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.60 | 01:07:44 | 39 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.61 | 01:07:45 | 39 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.62 | 01:07:46 | 39 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.63 | 01:07:47 | 40 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.65 | 01:07:49 | 39 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1652.67 | 01:07:51 | 39 | 0 | 31 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.68 | 01:07:52 | 39 | 0 | 46 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.69 | 01:07:53 | 40 | 0 | 46 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.74 | 01:07:57 | 40 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.75 | 01:07:58 | 39 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.77 | 01:08:00 | 40 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.80 | 01:08:03 | 39 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1652.81 | 01:08:04 | 40 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.05 | 01:08:25 | 41 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.06 | 01:08:26 | 40 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.19 | 01:08:37 | 41 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.20 | 01:08:38 | 40 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.21 | 01:08:39 | 41 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.22 | 01:08:40 | 40 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.23 | 01:08:41 | 41 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.25 | 01:08:43 | 40 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.28 | 01:08:45 | 41 | 0 | 70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.54 | 01:09:08 | 41 | 0 | -70 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.58 | 01:09:12 | 41 | 0 | -85 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.64 | 01:09:17 | 41 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.65 | 01:09:18 | 40 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.66 | 01:09:19 | 41 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.71 | 01:09:24 | 40 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.73 | 01:09:25 | 41 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.79 | 01:09:31 | 40 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.80 | 01:09:32 | 41 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.86 | 01:09:37 | 41 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1653.88 | 01:09:39 | 40 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.89 | 01:09:40 | 42 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1653.90 | 01:09:41 | 41 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1653.95 | 01:09:45 | 41 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1653.97 | 01:09:47 | 41 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |
| 1654.00 | 01:09:49 | 41 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | | | | | | | | | | | | | | |
| 1654.04 | 01:09:53 | 41 | 0 | -101 | 77 | 03 | 76 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | |